

VII INTERNATIONAL CONGRESS
MOUNTAIN AND STEEP SLOPES VITICULTURE

Extreme viticulture:
from a cultural landscape to an economic
and environmental sustainability

12-14 May 2022, Vila Real (UTAD)

Book of Abstracts



EDITED BY: Alberto Baptista

Universidade de Trás-os-Montes e Alto Douro (UTAD)

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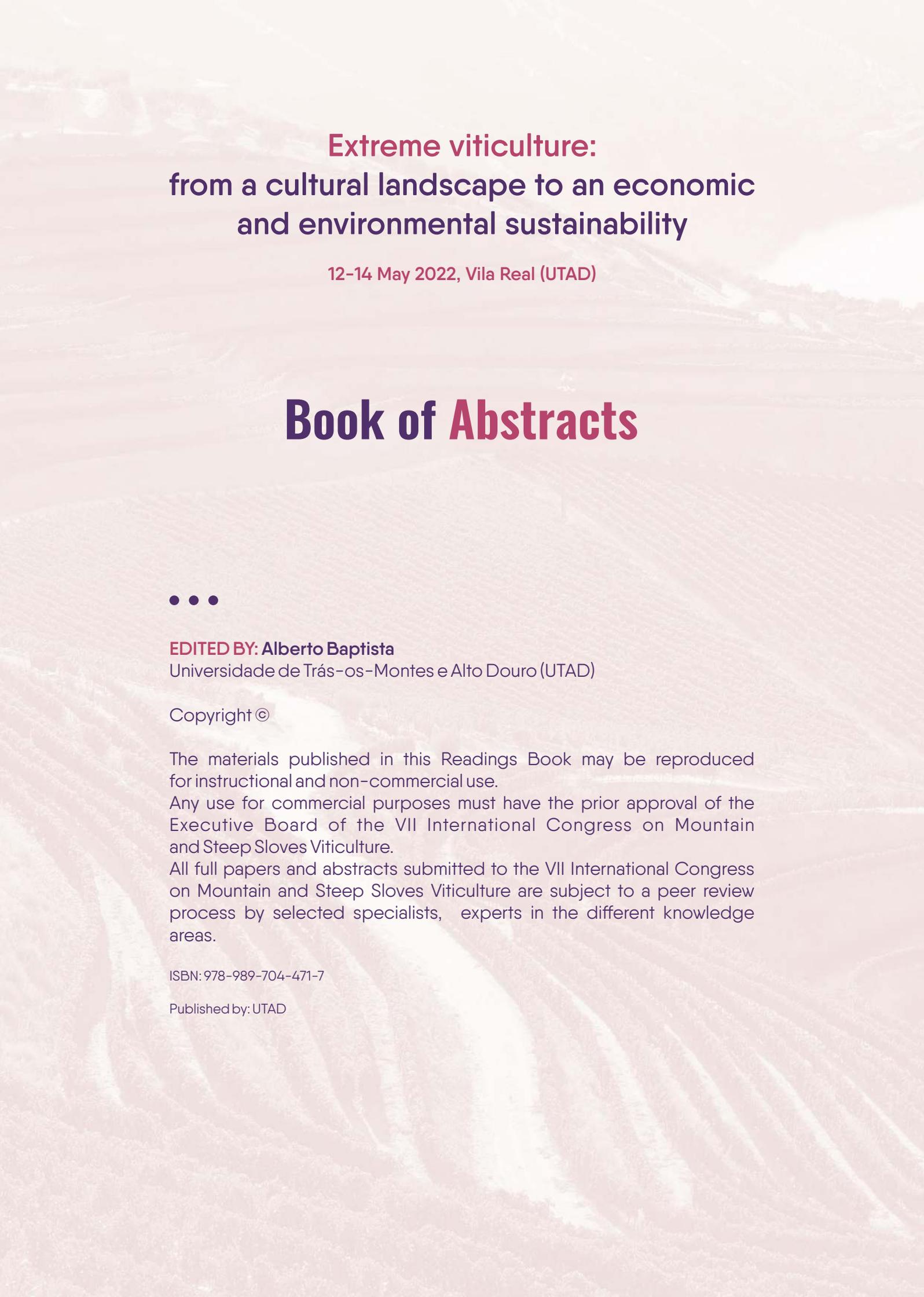
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PREÂMBULO

Em 2018 submetemos ao CERVIM a proposta para a realização do 7º Congresso Internacional de Viticultura de Montanha na UTAD, em 2020. Estávamos convencidos de que o congresso, a realizar em Vila Real e no Douro, seria uma importante oportunidade para divulgar e atualizar as inovações científicas e técnicas da viticultura e da enologia das regiões vitícolas de montanha. A pandemia adiou-o para 2022, pois estávamos também convictos de que a abordagem in loco era a mais adequada para o segundo objetivo que pretendíamos alcançar: promover a excelência da Região Demarcada do Douro (RDD), das suas gentes, cultura, paisagens vitícolas, vinhos e gastronomia.

A RDD é uma das regiões vinícolas regulamentadas mais antigas do mundo, conhecida pelo seu famoso Vinho do Porto e outros vinhos de alta qualidade. Dadas as suas características únicas, o Alto Douro Vinhateiro, uma parte da RDD, foi classificado como Património Mundial pela UNESCO, enquanto paisagem cultural evolutiva viva. A RDD é um vale que se estende por uma área de 250 000 ha ao longo do rio Douro, dos quais 18% são cobertos por vinhedos cultivadas em socalcos em zonas íngremes, em que mais de 58% das vinhas têm uma inclinação superior a 30%. É a maior região vitícola de montanha com cerca de 44 000 hectares de vinha, com uma produtividade média de 3500Kg/ha, produzindo cerca de 153 milhões de Kg de uva.

A viticultura no Douro apresenta condições de produção muito difíceis, resultantes da orografia, clima, dificuldade de mecanização e crescente escassez de mão-de-obra, fatores que contribuem para a elevação dos custos de produção, o que dificulta a competitividade dos vinhos produzidos na região no mercado global. As alterações climáticas tendem a agravar o desafio da sustentabilidade económica, ambiental e social sendo, por outro lado, fundamental elevar o valor do produto, para permitir pagar melhores preços aos produtores. Atendendo às características da DDR, fazia todo o sentido que o congresso sobre viticultura de montanha se realizasse nesta região.

Este congresso realiza-se no âmbito do CERVIM - Centro de Investigação, Sustentabilidade Ambiental e Avanço da Viticultura de Montanha, sob o patrocínio da OIV - Organização Internacional da Vinha e do Vinho, e foi organizado pela UTAD, que liderou, a Associação para o Desenvolvimento da Viticultura do Douro (ADVID) e a Faculdade de Ciências da Universidade do Porto (FCUP), com o apoio da Associação de Estudantes de Enologia e Viticultura da UTAD (ANEV). O evento contou ainda com o apoio de um vasto conjunto de parceiros institucionais e empresariais do território, como bem expresso ao longo do programa.

O Congresso inclui um extenso programa científico, visitas técnicas a quintas do Douro, mesa redonda com representantes institucionais regionais, eventos de demonstração sobre inovações tecnológicas e equipamentos, apresentação de casos de viticultura em condições extremas, e um interessante programa social. É também uma oportunidade para celebrar os 20 anos do Vale do Douro como sítio Património Mundial da UNESCO.

Reúne 74 resumos de comunicações, publicadas nas atas do congresso, que envolvem um total de 377 autores, provenientes de 10 países (Portugal, França, Itália, Espanha, Alemanha, Sérvia, Roménia, África do Sul, Eslovénia e Brasil). Os autores destas comunicações apresentam diferentes perfis, englobando um elevado número de académicos, profissionais da área, investigadores e estudantes de doutoramento. As temáticas apresentadas são muito variadas, com um grande foco na manutenção da sustentabilidade e da paisagem das vinhas em encostas íngremes e nas práticas agronómicas através do recurso a novas tecnologias. Adicionalmente, temos comunicações relativas aos fatores de qualidade para os vinhos, às pessoas, história, economia e cultura. Em todas as temáticas foram apresentadas diversas comunicações, abrangendo os 10 países indicados, com diferentes abordagens e metodologias, permitindo uma ampla discussão e visão crítica sobre o futuro da vinha em regiões de encostas íngremes de todo o mundo.

Esta publicação apresenta todos os resumos aceites e está estruturada de acordo com as 4 áreas temáticas do congresso, a saber: Tema 1. Manutenção da sustentabilidade e da paisagem em vinhas de encosta; Tema 2. Vinhas em áreas de montanha: melhoria das práticas agronómicas através de novas tecnologias; Tema 3. Melhoria dos fatores de qualidade do vinho; Tema 4. Vinhas em áreas de montanha: gente, história, economia e cultura.

O Vinho do Porto, a par dos vinhos de mesa produzido na região demarcada e controlada mais antiga do mundo, o Alto Douro, Património Mundial, dá-lhe as mais calorosas boas-vindas!

FOREWORD

In 2018 we submitted to CERVIM the proposal to hold the 7th International Congress on Mountain Viticulture at UTAD, in 2020. We were convinced that the congress, to be held in Vila Real and in the Douro, would be an important opportunity to disseminate and update the scientific and technical innovations of viticulture and oenology in mountain regions. The pandemic postponed it until 2022, as we were also convinced that the on-site approach was the most suitable for the second objective we wanted to achieve: promoting the excellence of the Demarcated Douro Region (RDD), its people, culture, viticultural landscapes, wines and gastronomy.

The DDR is one of the oldest regulated wine regions in the world, known for its famous Port Wine and other high quality wines. Given its unique characteristics, the Alto Douro Wine Region, a part of the DDR, has been classified as a UNESCO World Heritage Site, as a living, evolving cultural landscape. The DDR is a valley extending over an area of 250,000 ha along the River Douro, of which 18% is covered by terraced vineyards on steep slopes, with more than 58% of the vineyards having a gradient of more than 30%. It is the largest mountain wine region with around 44,000 hectares of vines, with an average yield of 3,500 kg/ha, producing around 153 million kg of grapes.

However, viticulture in the Douro presents very difficult production conditions, resulting from the orography, climate, difficulty in mechanisation and growing scarcity of labour, factors that contribute to raising production costs, which hinders the competitiveness of the wines produced in the region in the global market. Climate change tends to aggravate the challenge of economic, environmental and social sustainability and, on the other hand, it is essential to increase the value of the product in order to pay better prices to producers. Given the characteristics of the DDR, it made perfect sense for the congress on mountain viticulture to be held in this region.

This congress was held as part of CERVIM - Centre for Research, Environmental Sustainability and the Advancement of Mountain Viticulture, under the sponsorship of the OIV - International Organisation of Vine and Wine. It was organised by UTAD, which led, the Association for the Development of Douro Viticulture (ADVID) and the Faculty of Sciences of the University of Porto, with the support of the Association of Oenology and Viticulture Students of UTAD (ANEEV). The event also enjoyed the support of a wide range of institutional and business partners from the region, as expressed throughout the programme.

The Congress includes an extensive scientific programme, technical visits to Douro farms, round table discussions with regional institutional representatives, demonstration events on technological innovations and equipment, presentation of cases of viticulture under extreme conditions, and an interesting social programme. It is also an opportunity to celebrate 20 years of the Douro Valley as a UNESCO World Heritage site.

A total of 74 papers were presented and published in the congress proceedings, involving 377 authors from 10 countries (Portugal, France, Italy, Spain, Germany, Serbia, Romania, South Africa, Slovenia and Brazil). The authors of these papers have different profiles, including a large number of academics, professionals, researchers and PhD students. The themes presented are very varied, with a strong focus on maintaining the sustainability and landscape of vineyards on steep slopes and on agronomic practices through the use of new technologies. Additionally we have papers, with subjects relating to quality factors for wines and people, history, economy and culture. In all themes, various papers were presented, covering the 10 countries indicated, with different approaches and methodologies, enabling a wide-ranging discussion and critical vision of the future of vines in steep-slope regions throughout the world.

This publication presents all accepted abstracts and is structured according to the 4 thematic areas of the congress, namely: Theme 1. Maintaining sustainability and landscape in steep slope Vineyards; Theme 2. Mountain and steep slope Vineyards: improving agronomic practices thru new technologies; Theme 3. Quality-enhancing factors for "wines". Theme 4. Mountain and steep slope Vineyards: people, history, economics and culture.

Port Wine, along with the table wines produced in the oldest demarcated and controlled region in the world, the Alto Douro, a World Heritage Site, gives you a warm welcome!

AGRADECIMENTOS

Em nome da comissão organizadora do congresso, gostaria de expressar um conjunto de agradecimentos às pessoas, organizações e empresas que, de formas variadas e com diferentes intensidades, muito contribuíram para a sua realização e o seu sucesso:

Ao CERVIM, pela confiança depositada na UTAD em 2018, como principal responsável pela promoção do evento nesta universidade e no Douro, e pela estreita cooperação estabelecida desde então, que se traduziu na definição do formato e dos temas do evento e no apoio geral à sua concretização. Um agradecimento especial é devido a Roberto Gaudio, ex-presidente do CERVIM, e a Fernando Bianch de Aguiar, na qualidade de membro da Comissão Científica do CERVIM, por todo o apoio e disponibilidade, desde a concepção à realização do congresso;

Aos principais parceiros na organização, ADVID, FCUP e ANEEV, que desde o início do processo contribuíram para a sua definição e concepção e no apoio à sua execução. Como as organizações são constituídas por pessoas, um agradecimento especial é devido à Rosa Amador, da ADVID, ao Jorge Queiroz, da FCUP, e ao Gaspar Penha, da ANEEV;

Aos membros da comissão organizadora da UTAD, na pessoa do Vicente Seixas, da ECAV, que muito contribuíram no apoio à definição e realização do evento;

À reitoria da UTAD, na pessoa do Sr. Reitor, por todo o apoio prestado, designadamente em recursos humanos e equipamentos colocados à disposição da organização;

Aos membros da comissão científica, pelo seu contributo na seleção das comunicações, na pessoa do seu presidente Diego Tomasi;

Às várias instituições do território, com destaque para: o IVDP, que desde a primeira hora apoiou o evento, em particular na organização da *master class* sobre Vinho do Porto; a fundação do Museu do Douro, pela disponibilidade em organizar visita ao museu; ao Município de Lamego pela receção e visita a Lamego; Fundação da Casa de Mateus, que participou na organização e acolhimento dos congressistas;

A todas as instituições – UTAD, OIV, CERVIM IVDP, AEVP, CS-FRD, ADVID, CIM-Douro -, na pessoa dos seus representantes, que participaram na mesa-redonda e que deram o seu contributo para o debate sobre a sustentabilidade económica e ambiental do Douro;

Às empresas que acolheram os congressistas na visita técnica ao Douro, nomeadamente as Quintas do Bonfim, Ventozelo, Seixo e Carvalhas, e a todas as outras que ofereceram os vinhos para acompanhar as refeições, e ainda outras que, através da sua presença na exposição de equipamentos, apoiaram a realização das ações de demonstração.

Um agradecimento é também devido ao secretariado do congresso, muito em especial à Catarina Cepeda, que durante meses foi essencial no apoio à interação com os congressistas na organização do evento. Ao secretariado do CERVIM, na pessoa da Roberta Biondi, pelo trabalho de parceria e ligação com as estruturas do CERVIM.

Por último, em nome da comissão organizadora, um muito obrigado a todos aqueles que, de formas diversas, apoiaram e contribuíram para realização deste congresso e não foram aqui nomeados como mereceriam.

ACKNOWLEDGEMENTS

On behalf of the congress organizing committee, I would like to express a set of thanks to the organizations, companies and people who, in varied ways and with different intensities, have greatly contributed to its realization and its success:

To CERVIM, for the trust placed in UTAD in 2018, as the initial responsible for promoting the event at this university and in the Douro, and for the close cooperation established since then, which translated into the definition of the format and themes of the event and the general support for its realisation. Special thanks are due to Roberto Gaudio, former president of CERVIM, and to Fernando Bianch de Aguiar, as a member of CERVIM's Scientific Committee, for all their support and availability, from the conception to the holding of the congress;

To the main partners, ADVID, FCUP and ANEEV, that contributed from the beginning of the process to its definition and conception and in supporting its execution. As organisations are made up of people, special thanks are due to Rosa Amador from ADVID, Jorge Queiroz from FCUP and Gaspar Penha from ANEEV;

To the members of the UTAD organizing committee, in the person of Vicente Seixas, from ECAV, who contributed a great deal in supporting the definition and realization of the event;

To the rectory of UTAD, in the person of the Rector, for all the support provided, in human resources and equipment placed at the disposal of the organization

To the members of the scientific committee, for their contribution in the selection of papers, in the person of its president Diego Tomasi;

The various institutions in the area, especially: the IVDP, which supported the event from the very first moment, particularly in the organization of the master class on Port Wine; the foundation of the Douro Museum, for its willingness to organize a visit to the museum; to the Municipality of Lamego for the reception and visit to Lamego; the Casa de Mateus Foundation, which participated in organizing and hosting the visit of the congress participants;

To all the institutions - UTAD, OIV, CERVIM IVDP, AEVP, CS-FRD, ADVID, CIM-Douro -, in the person of their representatives, who took part in the round table discussion and made their contribution to the debate on the economic and environmental sustainability of the Douro;

The companies that hosted the congress participants on the technical visit to the Douro, namely the Quintas do Bonfim, Ventozelo, Seixo and Carvalhas, and all the others that

offered wines to accompany the meals, as well as others that, through their presence at the exhibition of equipment, supported the carrying out of the demonstration activities.

Thanks are also due to the secretariat of the congress, especially Catarina Cepeda, who for months was essential in supporting the interaction with the congress participants in the organisation of the event. To CERVIM's secretariat, in the person of Roberta Biondi, for the partnership work and liaison with CERVIM's structures.

Finally, on behalf of the organizing committee, a big thank you to all those who, in various ways, supported and contributed to the realization of this congress and were not named here as they deserved.

THEMATIC AREA 1

**Maintaining sustainability and landscape
in steep slope vineyards**

Assessing climate change vulnerability of mountain winegrowing regions in Europe

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Abstract

Many European winegrowing regions are located in mountain areas characterized by unique environmental conditions. These mountain viticultural areas (MVA) are particularly threatened by climate change which is increasingly altering local conditions and winemaking processes. The vulnerability to climate change is largely heterogeneous across different MVA because their ability to adapt to new climatic conditions and their sensitivity to climate change strongly depend on individual characteristics of each region. Therefore, not only projected changes in climatic conditions, but also socio-economic and legal characteristics must be considered to accurately determine the climate change vulnerability of individual MVA and develop tailored adaptation strategies. However, most existing studies focus on specific impacts and neglect important interactions between the different factors that determine climate change vulnerability. Here, we combine multiple indicators of adaptive capacity and climate change sensitivity with high resolution climate projections to provide the first comprehensive vulnerability assessment of MVA in Europe. We found that the climate change vulnerability of MVA largely depends on the complex interactions between physical and socioeconomic factors. Heterogeneous topographic conditions decrease climate change vulnerability and are critical to avoid the increased impacts of climate change. However, the varietal spectrum, the possibility for irrigation and the lack of financial resources are also important factors that can lead to increased climate change vulnerability. Our results provide the first vulnerability assessment for European MVA at high spatial resolution including multiple factors related to climate exposure, sensitivity, and adaptive capacity on the level of single winegrowing regions. This will support decision makers at all levels to identify hot spots of climate change vulnerability among mountain winegrowing areas and efficiently plan and direct adaptation strategies.

Economic and Environmental Balance in Viticulture: a case study in Douro Demarcated Region

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Abstract

Literature on the relationship of economics with environmental and social factors of grape production is very scarce. The analysis through the 'Carbon Footprint' has been corresponding to the environmental dimension, while the economic and social pillars have emerged in a market-oriented logic and strategies potentially influencing consumer behaviour, making it necessary to analyze their interactions from a perspective of balancing the dimensions that integrate the sustainability of production systems. This is the objective of this work, applied to a grape-growing farm in the Douro Wine Region, measuring the economic and environmental inputs and outputs in the viticulture phase, from 'Pruning to the Harvest', in a period of 5 campaigns (2015-16 to 2019-20). The operational activity was analyzed and recorded, field notebooks and operational accounting data of the holding were consulted to determine the production, costs, and profit of the campaigns. The environmental impact was calculated from the AgryBalise database, available at OpenLCA, using the functional unit 'kg of grapes'. The economic impact was calculated using the actual market values paid by inputs and received each year for the harvested grapes. The results are expressed in the functional units 'kg of grapes' and 'hectare'. The main results point to: i) 'labour work' as the highest cost factor, weighing 56.2% of the total, followed by 'mechanical traction' (without fuel) with 20.7% and 'phytopharmaceutical products' with 9.93%; ii) the factor with the greatest environmental impact (CO₂-Eq) is 'fuel', representing more than 60% of the total. In the years under evaluation, there is a low positive average profitability but greatly influenced by agricultural subsidies. The conclusions obtained suggest the need for environmental assessment of 'labour work' to be able to understand the true relationship of forces of its impacts with other production factors.

Identification and selection of indicators to evaluate sustainability in wine companies: a case study from a viticulture region of Portugal

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Abstract

Sustainability affects many sectors due to environmental, economic, social, or political reasons. Measuring, analyzing, and evaluating the sustainability of wine production can be a complex process, due to the multiple variables, production stages, and processes that are associated with it. However, sustainability methodologies are a powerful performance assessment instrument, a reliable communication tool, and a vital aid in the transition to more sustainable production models. The purpose of this study is to present a functional and adequate methodology, capable of facilitating the identification, selection, and aggregation of the set of indicators, in a balanced triple bottom line perspective, defined and adapted to the context under analysis, that allows the evaluation of the sustainability in the winegrowing sector. To achieve this goal, based on the Framework for the Evaluation of Natural Resources Management Systems, the following steps were put in place (1) construction of matrix sustainability indicators based on literature review; (2) identification of critical points and determination of diagnostic criteria; (3) participation of the company's internal collaborators in the sustainability discussion; (4) verification and validation of indicators; and (5) proposal of final sustainability indicators integrated on the sustainability attributes. The methodology developed in this study corresponds to a flexible, participatory, and well-adapted tool for sustainability assessment in the winegrowing sector. The findings allow us to identify that a careful identification of critical points (e.g. water and energy consumption, soil and biodiversity conservation, distancing from the surrounding community) in a system is the key to achieving the consideration, through diagnostic criteria (e.g. Productivity, efficiency, diversity, conservation, and protection of natural resources, and social participation and integration), of all sensitive areas in sustainability assessments. Annual corporate sustainability evaluations would allow outlining their strategies to adapt to the context of the wine sector, become more competitive and improve their business performance.

Impact of phytosanitary threats under climate change scenario in Demarcated Douro Region

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Abstract

Grapevine diseases caused by fungi agents are a growing and worrisome challenge to viticulture. Since the phenological stage of visible inflorescences, grapevines are susceptible to downy mildew infections, followed by powdery mildew infections from bunch closure. In the Demarcated Douro Region (DDR), this reality has a significant impact, especially, under a climate change scenario. Therefore, the adaptation of vineyards' phytosanitary state management has become crucial to the viticulture ecosystem sustainability. In Portugal, the research about the influence of climate change in the incidence of grapevine diseases is still very scarce. Building up this information, the present work aimed to correlate the incidence of the main grapevine diseases of DDR – downy mildew and powdery mildew – with climatic conditions in five seasons (from 2017 to 2021). The incidence of grapevine diseases was measured at the phenological stages in which grapevines were more susceptible to pathogenic infections: flowering, bunch closure, verais on and at harvest. The disease incidence was estimated through visual observations of leaves and bunches of 20 plants of the viticulture observatory of ADVID (Associação para o Desenvolvimento da Viticultura Duriense). This observatory consists of a network of vineyard reference plots, distributed along with three sub-regions of the DDR (Baixo Corgo, Cima Corgo and Douro Superior), where edaphoclimatic, viticulture, and biological information was continuously collected by automatic weather stations. The current study confirmed that accumulated precipitation and relative humidity have increased, leading to early infections by fungi pathogens, especially during the period between flowering to bunch closure (to downy mildew) and between verais on to harvest (to powdery mildew). Moreover, the instability of the climatic conditions caused by global warming will allow a quick spreading of grapevine diseases through the DDR, as observed for downy mildew, which has appeared earlier due to high precipitation and relative humidity, particularly in the Baixo Corgo sub-region.

Influence of soil management on the risk of erosion and the performance of a steep slope vineyard under a sub-humid climate

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Abstract

Tillage is a common vineyard soil management strategy reducing competition for water and nutrients between grapevines and other plants. However, in vineyards located in steep slopes and humid regions, such as Ribeira Sacra (NW Spain), cover crops and mulching might be an advantage for reducing the soil erosion risk caused by rainfall, improving soil water retention and decreasing direct evaporation of water from the soil, while reducing management costs. The current study was conducted in 2019 to assess the effects of three soil management strategies (tillage, mulching and native vegetation) on soil erosion, grapevine water relations and yield. The experiment was carried out in a vineyard of the cultivar ‘Mencía’ (*Vitis vinifera* L.) located in Ribeira Sacra (Lugo, NW Spain). The treatments were replicated three times and the methods employed included erosion pins, pressure chamber, leaf porometer, chlorophyll content meter, yield and pruning weight. Soil depletion occurred in all treatments: tillage (0.84 Mg ha⁻¹), native vegetation (0.42 Mg ha⁻¹) and mulching (0.36 Mg ha⁻¹). Midday stem water potential was more negative in the native vegetation treatment, whereas that of the vines under the mulching treatment did not differ from the tillage control. However, these differences did not have a translation in leaf stomatal conductance or chlorophyll content index. Although a trend to a reduction in yield was observed in the native vegetation treatment when compared to tillage (up to 20%), this difference was not significant due to the high vine-to-vine variability. This yield reduction occurred through a combination of less clusters per vine and a lower cluster weight (81% of the weight under the tillage treatment), which was significantly higher for the tillage treatment than for mulching and native vegetation. These results suggest that mulching and native vegetation can be alternative soil management strategies in humid climates.

Mapping mountain viticulture areas in Europe: a GIS-based inventory

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Abstract

Mountain viticulture areas (MVA) shape important economic, environmental and cultural values and are often tied to distinctive climatic and topographic conditions. Over recent decades, these landscapes have been increasingly studied for their vulnerability to a set of drivers such as socio-economic dynamics and climate change. However, a systematic mapping of MVA in Europe has never been carried out. At the state of the art, the quantification of existing MVA in Europe is mostly based on statistics provided by local and regional authorities that are often aggregated at different spatial scales. In this study, we aim at identifying and analysing MVA in Europe using a geographical information systems approach. To map European MVA, we used the geo-topographic criteria defined by the Centre for Research, Environmental Sustainability and Advancement of Mountain Viticulture and extracted the relevant viticultural areas from Pan-European land cover datasets. The output consists of a geographical dataset that classifies MVA based on specific characteristics: an elevation greater than 500 meters and/or slope greater than 30%, the presence of terraces, the localization on small islands. The inventory will allow further studies on MVA, supporting land managers, planners and regional authorities, and will constitute a primary reference for the development of spatially explicit decision making. This includes the support in processes regarding planting rights and funding in the context of climate change, the evaluation of vineyard management and adaptation strategies that can be used by farmers, or the assistance in possible issues related to landscape planning.

Planning sustainability initiatives for mountain wine regions: a critical review of available assessment tools

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Abstract

Despite heroic viticulture appellation resembles bold and noble connotations, associated territories and wine communities are extremely vulnerable to climate change impacts. Considering OIV recommendations on the process of planning for sustainable activities based on sustainability and risk assessment, a three-step research was developed. The goal was to identify significant orientations to implement such activities and assess their effectiveness. After the scrutiny of 105 sustainability assessment tools, a structured critical review over 42 instruments allowed to assort seven of the most suited tools for decision-making and to evaluate mountain viticulture: EIOVI; FESLM; IDEA; INDIGO; INSPIA; ISAP; and SAFE. Afterwards, major strengths, weaknesses and opportunities were analysed in accordance with mountain areas inherent needs to delineate a resilience action plan based on short-to-long term strategies for steep slopes viticulture. Findings showed that the majority of these tools not only neglected or overlooked social and economic dimensions, but were mostly designed to contribute with analysis interpretation, rather with education or knowledge transference. Thus, it was concluded that further research of this nature is still necessary at mountain winegrowing context as methodologies available to holistically assess sustainability are not sufficient suitable yet. It is also proposed that any sustainability strategy and initiative designed for heroic viticulture, in particular mountain areas with geographically highly valued landscapes or cultural assets such as the UNESCO world heritage sites classification, should transcend traditional technical evaluations and integrate local socio-economic and cultural aspects. Such consideration is beneficial to sustainability due to their strong connection with the surrounding communities, culture and history of the region. This work is the foundation for further and deeper research to ensure continuous control and improvement regarding sustainable decision-making and resilience building on such heroic scenarios.

Simulations of water flow and soil erosion under different Soil and Water Conservation (SWC) practices in traditional vineyard landscapes

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Abstract

One of the key challenges for the environmental sustainability of traditional vineyard landscapes is the mitigation of soil erosion. Steep-slope vineyards are commonly prone to land degradation ranging from subtle processes (e.g. sheet erosion) to large-scale slope failure events (e.g. terrace collapses or landslides). In Italy, there is a long-standing tradition of diverse Soil and Water Conservation (SWC) techniques aiming to limit erosive processes, such as different types of terraces. This study offers a novel comparison of three commonly used steep-slope cultivation patterns: (i) dry-stone walls terraces (Italian: muri a secco); (ii) non-terraced slope-wise cultivations (Italian: rittochino); and (iii) earth bank terraces (Italian: ciglioni). In addition to the three hillslope practices, a set of sediment traps and drainage ditches were analysed in order to evaluate the potential mitigation of erosion and runoff. Spatial patterns of water flow and soil erosion were simulated in high-resolution using the physical model SIMWE for novel process visualisation/quantification. Results show that terraces can effectively safeguard large areas from soil loss (compared to rittochino); however, under severe rainstorm conditions, even terraces can cause runoff concentration and subsequent large-scale damages (e.g. landslides). This emphasises the importance of appropriate terrace designs, aiming to prevent concentration and promote controlled drainage. Conservation structures such as sediment traps or ditches may help reducing erosion on hillslopes (-15.3% in our study) and downslope water excess (-42.9%). This research illustrates how high-resolution flow simulations can and should be incorporated in the design of SWC practices as mitigation strategies in high-value traditional landscapes.

Steep slope vineyards facing tomorrow's challenges: territorial externalities, wine tourism, climate change, biodiversity, robotization, global food challenge

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Abstract

Steep slope vineyards are most often the result of ancestral know-how but are sometimes threatened due to the extra cost of grape production, the lack of manpower and the reinforcement of regulatory aspects. Nevertheless, this type of viticulture has a strong qualitative value and many externalities, notably heritage and ecological. The abandonment of these vineyards contributes to a loss of local biodiversity, to an abandonment of these rural territories, to an increase in the risks of fire and sometimes of runoff and erosion, in parallel to the loss of heritage value, support of wine tourism. It is important that these heroic, fragile vineyards can integrate the issues of tomorrow within the professional world, but also at the level of decision-makers in the regions, states, the European community, which intervene in the regulations and financial tools. With regard to climate change, if the terraced system allows for the optimization of sunlight, traditional agro-forestry approaches as well as the adaptation of grape varieties and management methods can be considered. With respect to mitigation, it is important to emphasize that these territories contribute to a generally higher carbon storage than natural areas, an aspect that should be quantified and defended in a perspective of strengthening this issue. The gradual introduction of digital technology and robotization, given the difficulty of finding a workforce in these areas with a certain amount of hard work, will probably make it possible to respond to the particularities of technical itineraries, provided that technological advances take into account the specificities of steep slopes. Finally, the increase in the world population and the decrease in agricultural yields will probably result in the next few decades in a challenge to ensure food security at the global level, hence the importance for the wine sector to conserve production areas that are not very valuable from a strictly food point of view.

The (missing) 'edge': reviewing the terraces geometry in the Douro region towards sustainable viticulture

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Abstract

The Douro Region constitutes over 50% of the world vineyard mountain area. After a first generation of terraces supported two rows of vines, the narrower single vine row is now dominant. The terrace riser gradient is a key element in the vineyards construction. Bibliography on the subject is relatively scarce and there is little consensus in the definition of the riser gradient. The recommendation made by the official institutions to the riser gradient is about 175% to 200%. However, empirical observation and practical experience revealed that is impossible to fulfil these criteria leading to a reappraisal of the terraces building techniques, namely related to a viable riser gradient. A study was carried out to assess the values of the riser gradient (with 900 measurements), and with GIS supported data and high-precision digital elevation models and continuous gradient measurements over large areas. The results showed that the riser gradients range from 90% to 110%. The resultant geometry implies lower plant densities, which means less efficient land usage and lower financial income. However, these numbers are in accordance with established parameters in regions with hillside vineyards, including issues such as terrace stability, and erosion control. The results point the advantages of adopting less steep risers in the terraces construction and served also to evaluate erosion susceptibility in varying terrace geometries. With the aim to develop a code of good practices, a study is conducted to evaluate bank gully erosion modeling and riser instability in a one wine row terrace layout. The modeling process use a physical based model, SIMWE (SIMulated Water Erosion). The validation process is based on a rainy episode of 120mm/h (May 28th, 2018). Two detailed digital elevation models, one before the erosion process and other two days after, support de terrain information for the modelling and validation. These results contribute to the proper evaluation of vineyard parcels, following EU guidelines, whilst also addressing the reality of Douro vineyards and mountain viticulture in general.

Vineyard Observatory in the Douro Demarcated Region for a more Sustainable Steep Slope Viticulture

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Abstract

On the perspective of applying more sustainable strategies in the Douro Demarcated Region (DDR), in 2014, ADVID implemented a Vineyard Observatory (VO). It consists in a network of 25 reference vineyard plots distributed along the three sub-regions of DDR (Baixo Corgo, Cima Corgo and Douro Superior), in order to obtain a greater representation according to their climatic differences, namely temperature and precipitation, altitude, exposure and some of the most representative varieties of the region such as cv. Touriga Franca, Touriga Nacional, Tinta Roriz, and Moscatel Galego. In these plots, data related with vineyard (vegetation, production and quality parameters of grapes), pest, diseases and climate evolution are collected throughout the year in a close collaboration between ADVID team and the technicians of ADVID associates. The goal of the VO is to build a strong viticulture database that can be used either by researchers to develop and calibrate several models (grapevine phenology and pest and disease prevision), as by service providers in order to calibrate several available tools. The final goal is that DDR growers use the information produced in decision support management tools, for more precise application of inputs and tasks, contributing for a higher sustainability of their vineyards. From the collected data throughout these last eight years (2014-2021), a grapevine phenological model is being developed and serving as a tool to support the wine sector in predicting some phenological events (budburst, flowering and “veraison”), indicating whether the vegetative cycle is more delayed or advanced, in relation to the average. The use of these tools contributes for a more precise management of the crop production operations done on the vineyards, as these show us with some antecedence the possibility of intervening opportunely. To support this model or others that can be developed, we will continue to collect this data with precision in order to ensure a better reliability and coherence of the results obtained.

Herbicide application on Douro vineyard soils: are the ecosystem organisms affected?

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Abstract

Herbicides, commonly applied in the vine line for weed control, are becoming a concern in Portuguese vineyard soils. Studies show that these soils have the highest concentrations of the herbicide glyphosate and AMPA (it's degradation product) comparing with other EU countries, reaching concentrations of 2 mg kg⁻¹. Even though glyphosate degrades at a high rate and has a relatively short average half-life in the soil, it can strongly adsorb to organic matter or even move to other compartments of the ecosystem, negatively affecting terrestrial and aquatic organisms. By performing ecotoxicological assays, it is possible to understand to which extent these organisms are affected by these pesticides. Taking this into count, this work aims to assess the effects of herbicide application on aquatic and terrestrial organisms.

This study took place in two vineyards from the Douro Demarcated Region that were under integrated protection mode (IPM). About six soil samples were collect in each vineyard in February during herbicide application and April, two months after this application. In the context of this work, some ecotoxicological assays with aquatic (growth inhibition assays with *Raphidocelis subcapitata* and *Lemna minor* and bioluminescence inhibition assay with *Allivibrio fischeri*) and terrestrial organisms (avoidance assays with *Eisenia fetida*, seedling emergence and growth with *Medicago sativa* and reproduction assays with *Eisenia fetida* and *Folsomia candida*) were performed. Overall, it seems that herbicide application was more detrimental to the aquatic species as well as the plant species *Medicago sativa*, comparing with the other terrestrial organisms.

Electrical Resistivity Tomography for soil moisture estimation in terraced vineyards: a case study in the Douro Region, Portugal

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Abstract

The Douro Region (Portugal), with an extension of ca. 43 000 ha of vineyards, is one of the most important wine regions in Europe and listed as a World Heritage site (UNESCO 2001). This is a supplementary reason for actions to preserve its natural resources such as soil and water. The regional topography exposes soils to severe erosion risk. In order to mitigate these risks, vineyards are installed in conservation structures typical of this area, called Terraços or Socalcos (Terraces). These structures require important earth movement to secure them properly which results in strong disturbance of soil structure and soil water movement. The aim of this study is to compare soil water content of a terraced vineyard in the wet season (January) with that in the dry season (July), using Electrical Resistivity Tomography (ERT). ERT has been broadly used to assess soil water moisture, also in vineyards. However, in this case it is necessary to consider the complex topography of the terraces in order to obtain a reliable soil profile model. The study was carried out in a terraced vineyard at Peso da Régua. ERT transects were measured in three neighbouring areas of the vineyard: Terrace, Inter-terrace and Terrace. Transects in the Terrace areas were parallel to the slope while transects in the Inter-terrace area were perpendicular to the slope. Six transects were carried out (three in January and three in July in the same positions). Electrode spacing along the 20 m transects was 0.5 m. Also, soil samples were taken at 4 depths (0.0 - 0.5 m; 0.5 - 0.10 m; 0.10 - 0.20 m; >0.20 m) for gravimetric water content determination. ERT data obtained were inverted considering the topography, to obtain soil electrical resistivity profiles. For this case study, ERT results provided an adequate representation of soil moisture profiles, offering possibilities of fast and detailed appraisal of soil water content and distribution in terraced vineyards.

Shoot removal applied just before bloom for vegetative productive adjustment: agronomic and qualitative effects on cv. Verdejo in the DO Rueda (Spain)

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Abstract

The relationship between vegetative development and grape production can be a critical aspect to approach the balance of the vineyard and improve the quality of the grape in white varieties, depending, among other factors, on the water conditions of cultivation. The Verdejo variety is intensely spreading its vineyard in various zones, so it is important to know its response to the reduction of its vegetative expression in order to favor the quality of grapes. Throughout the 2015-2018 period, the application of shoot removal (D) was studied, pulling out 6 of 16 shoots (to keep 10 per vine) of each vine, compared to a control treatment (T). The trial, located in Medina del Campo (Valladolid), within the D.O. Rueda, was carried out with cv. Verdejo on rootstock 110R, planted in 2006 and trellis trained as bilateral Royat cordon, with vine distances of 2.60 m x 1.25 m (3,077 vines/ha). The water management was through deficit irrigation: 30% of ETo applied by dripping weekly from the beginning of veraison to harvest. The vines subjected to shoot removal reduced the weight of pruning wood by 15%, despite the increase in the weight of shoot. Likewise, the shoot removal reduced grape production by 31%, as a consequence of the decrease in the number of bunches. The shoot removal favored the concentration of sugars, as well as, to a lesser extent, the pH and the concentration of potassium, while the total acidity and tartaric acid did not show a definite or constant interannual trend, and the malic acid showed annual values with an inverse tendency between treatments with respect to tartaric acid, without remarkable differences between treatments. These results correspond to a certain intensification of the grape ripening process, conditioned by the increase in the leaf/fruit ratio due to shoot removal. Definitely, it can be deduced the possible usefulness of shoot removal in seasons where there may be a delay in the ripening process, in order to optimize the grape harvest date and quality, according to the objectives pursued.

Two different terraced protected areas: to which extent are biodiversity and soil functionality influenced by agronomic management?

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Abstract

Despite having a very long history, mechanisms behind terracing and the overall effects of this technique are still poorly faced, mainly regarding biodiversity and ecosystem services. In the SCREENBIO project, two different Italian geoclimatic terraced agroecosystems were selected: 1) Cinque Terre National Park (Liguria Region), with 6 coastal vineyards; 2) Majella National Park (Abruzzo Region), on high mountains, with 2 agropastoral sites and 4 vineyards. Soil assessment included 3 elements: chemical analysis, soil enzymatic analyses, ecological surveys of microarthropods. Soil samples were characterized for both chemical (Corg, Ntot, pH, available P) as well as for biochemical properties (16 enzyme activities) as indicators of the intensity of C, N, P, S biogeochemical cycles. In addition, soil microbial biomass was estimated using double-strand DNA (dsDNA) content in soil. The abundance and biodiversity were evaluated by the main ecological indexes. In vineyards, furthermore, leaf epigeic acarofauna was evaluated. Chemical and bio-chemical characterization evidenced significant differences that could be ascribed to both geopedological origin and agronomic history of different locations in both Majella and Cinque Terre National Park. In general, microbial biomass showed a good correlation to Corg content, but the intensity of biogeochemical processes was different according to different managements. The soil microarthropods recorded in terraced vineyards represents 85-90% of edaphic mesofauna. Oribatidacari and other secondary consumers are affected by soil management. On vine leaves, predator mites as bioindicators were absent or rare in Majella and Ligurian conventional vineyards. The highest densities were registered in Liguria, on Albarola cultivar. In topsoil, such estimates can be integrated to calculate diversity in micro- and meso-web. This step may implement knowledge, depending on importance given to changes in community structure, to provide the basis for a comprehensive, harmonised soil information system.

Brda/Collio terraces - a millennial heroic heritage of landscape

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Abstract

Brda/Collio is known as the landscape of a thousand terraces, which after World War II was divided into its Slovenian (Brda) and Italian (Collio) part, despite the common social history and the traditional cultural landscape. After the first settlements in Brda (B.C.), food production was limited only to the fertile plains, where the produced food quantity has become insufficient, deteriorating further upon the arrival of the Romans. For this reason, the inhabitants of that time were forced to find new cultivation areas, this time on the slopes of the steep hills with unfertile soil, which they had to transform into usable land. The topography of Brda comprises several NE to SW oriented ridges peaking 200-450 m above sea level, with quite steep slopes (up to 70%), which were formed during the Alpine orogeny (20-5 mio years ago). Brdais characterised by the unfertile flysch soil and a sub-Mediterranean climate, while the vicinity of the Julian Alps causes an unusually abundant precipitation of 1.600 mm/year and consequent intense soil erosion and landslides, which is the reason why the terraces become indispensable in Brda. Supported by archaeological findings and reports, these landscape transformations dateback to 3rd-4th century A.D., the first technical plan of Brda terraces datesback to studies of the Franciscan cadastre (1824). The Brda terrace is characterised by a tread (bed) and scarp (riser) constructed merely from the soil, with a scarp width: height ratio = 1 : 1, and 2.5-3.5 m of tread width. Brda terraces are traditionally flat, relatively short around 80-100 m and partly surrounded by ecological niches; in order to preserve biodiversity and habitats of different endemic animals, reduce the intensity of grape/fruit production, reduce the impact of water and wind erosion, etc. Due to climate change and more EU restrictive agriculture policy, the costs of food production constantly increase causing less interests for agriculture what affects the land use and architecture.

3D relative differences of soil water content over a growing cycle in a rainfed vineyard with two varieties and homogeneous ground conditions

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Abstract

Proper understanding of the soil water content (SWC) dynamic is necessary for any farming type and becomes relevant in rainfed cropland. Monitoring of soil physical properties at high spatial and temporal resolution offers relevant information in precision farming. In this study, we characterize the spatial patterns of SWC and their temporal stability in a small organic vineyard located near Betanzos (Galicia, Spain). This field includes two vine varieties ('Agudelo' –*Chenin blanc*– and 'Blanco Legítimo') and vines are ca. 25 years old. The mean slope gradient is 38%, and climate is temperate oceanic, with mild, rainy winters and cool, quite sunny summers. Twelve capacitance-based technology *Sentek Drill & Drop Bluetooth*[®] soil moisture probes were installed on February 26th, 2021, and have been measuring SWC from that date on. Six probes are devoted for each variety (three in the rows and three in the inter-row areas), and SWC is measured every 15 min at 5, 15 and 25 cm depth (3456 values of SWC per day). Homogeneous ground conditions with spontaneous vegetation covering the whole field remained until 26th October, when soil was ploughed.

The relative differences(it) were calculated at each measurement point considering the vertical profile (3 points per probe) and the horizontal profile (12 points per soil depth). Then, the mean relative difference, the standard deviation of the relative difference, and the coefficient of variation were calculated to characterize the 3D spatio-temporal patterns of SWC. Results were analysed for the whole period (242 days), and three soil moisture periods: drying and warming, warm and dry, and cooling and wetting. We also found differences between the two varieties, and between the rows and inter-row areas. Finally, any combination of field compartment, soil depth and vine variety was investigated to refine the comprehension of the actual dynamic of SWC in a small field with homogeneous edaphic, topographic and management practices.

A zoning approach to study a viticulture district in a small island of the Mediterranean basin

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Abstract

The influence of environmental factors, including climate, physiographic features (altitude, slope, exposure, etc.), and soil on grapevine accomplished by geographical data can be used to divide territories into homogeneous zones. It is important for viticulture zoning to establish if these areas have unique and homogeneous characteristics. In this study case, a zoning approach is adopted to differentiate viticulture areas and to recognize homogeneous sub-areas. Previous research has underlined the environmental potential for producing quality wines on the small island of Sardinia (Italy). A preliminary photo-interpretation using satellite images, obtained from Sardinia Geoportale, developed by the Autonomous Region of Sardinia (RAS), supported the zoning division phase. The zoning divided the study case into 3 macro-areas: the first in the north-west, the second in the north, and the third in the south-east; each of the areas was separated to obtain 20 overall sub-areas, where the vineyards have been identified during this study. The geographical and environmental data were added to a geodatabase in GIS software jointly with the GPS survey records collected, the latter was used as a proof grid to confirm the photo-interpretation results. In addition, a set of observations regarding plant density, trellis system, yield, and must quality was added at geodatabase to generate viticulture suitability maps, useful to distinguish areas for wine production; these results underline the applicability of this approach also in land-use planning and management. The geographical data have been included in the WebGIS platform of Laore, Agency of RAS.

Agro-environmental P evaluation in vineyard soils from the Douro Valley Region

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Abstract

The accumulation of phosphorus (P) in agricultural soils and its transfer to waters is a concern in terms of the environment and the sustainability of natural resources. Relating soil P with P sorption capacity (PSC), the degree of P saturation (DPS) was proposed as an index for P risk assessment, with a critical value of 25% in non-calcareous soils for P loss to waters. Assessments of DPS and extractable-P, Olsen (POIs) and Ammonium-Lactate (PAL) were performed in 122 soils of Douro valley vineyards. According to the K-S test, both extractable-P and DPS values showed non-parametric positively-skewed distributions ($p < 0.001$), while the PSC was normal distributed ($p > 0.05$). The median and mean DPS values were 16.9 and 22.1%, respectively, below the critical value. Nevertheless, nearly a third of the soils showed DPS > 25%, pointing out the importance of a sound P management. On average, the POIs values were about 3.5 times lower than PAL, being the differences between both methods significant (Wilcoxon sign test, $p < 0.001$, $n = 122$). More important than the absolute values, the agronomic interpretation for soils fertility showed also evident differences between methods. For POIs, nearly 79% of the soils are classified as low/very low and 13% are classified as high/very high, and with both median and mean values on the low/very low class. For PAL, about 47% of the soils are in the low/very low class and 26% are classified as high/very high, with both median and mean values standing in the medium-fertility class, revealing a possible overestimation of soil P status by the Ammonium-Lactate method. It is also relevant to note the observed distribution of the assessed parameters since the human-altered parameters revealed non-normal distributions, opposed to the PSC, an intrinsic soil characteristic.

Assessing soil erosion rates in vineyards using the RUSLE model: an insight on the topographical factor (LS) and how its calculation can affect erosion estimates

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Abstract

Soil erosion is an important issue, especially in sloping areas such as hilly and mountain regions, where vineyards are typically grown. Different types of ground cover can be applied to reduce soil losses, although multiple factors affect this phenomenon. Among several models developed to predict soil erosion rates, the Revised Universal Soil Loss Equation (RUSLE) is one of the most widely used, for both plot and wide area level (e.g., catchment or region). This empirical model considers different factors to describe erosion risk: rainfall erosivity (R), soil erodibility (K), cover and management (C), slope length and steepness (L and S, often considered jointly), and support practices (P). Among those, the topographical LS factor can be derived from a Digital Elevation Model (DEM) in a GIS environment.

A multitude of algorithms have been developed to obtain this factor automatically from DEM. Differences between operator-measured LS values and the results obtained using different algorithms in SAGA GIS were tested, and the resulting soil losses compared. The study area considered in this work was set in the Alto Monferrato hilly area, in the province of Alessandria. We considered DEMs with different geometrical resolution (5, 10 and 25 m) for every tested algorithm. Although algorithms may tend to overestimate (or underestimate) LS, an automated calculation procedure can reduce operational times, also lowering the risk of human failure during this part of data elaboration. Linear regression helped identifying the best combination of algorithm and input resolution. As expected, DEMs with a higher resolution gave the best results (R² 0.8) for all algorithms, also providing information on the spatial variability of this factor within the field. Soil losses estimates equally displayed certain degree of variability (average coefficient of variation: 30%), highlighting the importance of correctly assessing this factor.

Fungus resistant grapevine varieties: agronomic and oenological assessment in two alpine valleys

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Abstract

In mountain viticulture, phytosanitary treatments are one of the most time-expensive operations for farmers, due a difficult mechanization, with relevant effects on the economic sustainability of the cultivations. Thus, in the last decades, several vineyards located in marginal areas were abandoned, with a negative impact on ecosystems diversity and landscapes value. Furthermore, mostly of vineyards in mountain are close to relevant natural areas, so reducing environmental impacts of cultivation is even more important. Recently (2009), Italian legislature allowed the cultivation of disease resistant grapevine varieties (interspecific hybrid tolerant to some fungal disease), that required less phytosanitary treatments than traditional varieties and could become an interesting solution for a low environmental-impact and economically sustainable viticulture in alpine marginal areas. Anyway, on field-assessment of this cultivars is necessary, to suggest the best choice for specific pedological and climatic conditions. To reach this purpose, some resistant varieties were analysed in two alpine valleys (Valtellina and Valcamonica, Lombardy Region, Italy). During the season, phenology and disease tolerance were evaluated. At harvest, technological maturity, fertility and productivity were assessed. Furthermore, grapes from each cultivar were separately vinified. The wines obtained were tasted by an expert panel. Analysing data, mostly of the tested cultivars can reach technology maturity and good production despite severe climate condition. Tolerance to the diseases would seems good. About the most interesting results, it seems that Solaris is characterized by an elevate sugar accumulation and productivity, also if cultivated at high altitude. Souvigner Gris has a later maturation and maintain an interesting acidity and a good sugar accumulation. However, cultivars as Aromera, that show, at harvest, low acidity, low sugar content and low production, could be not adapt in these specific environmental conditions.

Effects of some extreme rainfall events on Hydrological and Soil Erosion Processes in Tilled and Grassed Vineyards

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Abstract

First step in optimizing the use of water and soil in sloping vineyard is avoiding water losses and erosion by runoff, improving water infiltration. In mechanized vineyards, machines traffic is responsible for soil compaction, this can result in soil degradation, affecting many soil ecosystem services, such as the role of soil in supporting nutrient cycle and thus soil fertility, regulating soil water availability, biodiversity, carbon sequestration, erosion protection. When the use of machinery is fundamental, it is crucial to know its impact on soil compaction, that directly affects soil physical properties negatively, resulting in reduction of soil porosity, of water infiltration capacity and increased runoff and consequent erosion, with decrease of storage and supply of water in the soil. The study was conducted in a sloping vineyard located in Piedmont, NW Italy. Rainfall characteristics, runoff and his turbidity, soil erosion, and soil water content were hourly measured during extreme events occurred in the last two years (October 2019 - October2021), in two different inter-row soil managements: 15 runoff events were recorded, 7 of which due to extreme rainfall with more than 100 mm in the autumn/winter period. Results show how the soil management adopted in a trafficked vineyard strongly influences the infiltration and water retention capacity of the soil and the risk of erosion. Indeed, the grass cover halves the runoff and reduces the soil erosion by 1/3, compared to conventional tillage. Extreme rainfall events were responsible for more than 90% of the runoff and 95% of the soil eroded in the period (>6 t/ha), highlighting the need to improve the environmental sustainability of these agricultural systems, considering the challenge of climate change, with forecasts indicating increasing temperatures and decreasing rainfall in the Mediterranean region associated with extreme events such as drought and intense rainfall.

Symington grape libraries: a tool for climate change adaptation

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Abstract

Climate change is causing concern to vine growers all over the world. To face this scenario of change fresh approaches and practices will have to be adopted, like selecting the best suited grapevine varieties, in order to be able to continue producing high quality grapes and, by extension, exceptional wines. The main objectives of this project are to gain knowledge of the grape varieties planted in the Douro, namely of their viticultural and oenological potential, with a focus on forgotten varieties. Through the study of the genetic diversity of these varieties, including dynamics of the phenological phases and winemaking potential, the aim is to better understand specific varieties' adaptability to heat and water stresses, to reduce vulnerability to climate change. Furthermore, grapevine phenology is considered one of the first biological indicators of climate change, and therefore one of the most important factors to be studied in varietal adaptability. The grape libraries were established in 2014 to study the adaptability of different varieties to specific climate conditions. There are represented some grape varieties, comprising indigenous Douro and Portuguese varieties and 5 foreign varieties. The methodology followed consists in determining the average date for the principal grapevine phenological stages: budbreak, flowering and version; performing observations in 10 vines, in 4 different points, three times a week, during the period estimated for the phenological stage, assigning a percentage of developing/evolution. This percentage is an empirical evaluation, based only on visual observation and observer experience. With those readings, using a formula that relates the date and the reading recorded on the last observation before reaching the level of 50% with the day that attains or passes 50%, it is possible to define the date (average date) of selected phenological stages. This work has been carried out through 5 seasons, with different climate conditions. The first results show differences in the vegetative cycle duration between varieties, this will help to acquire knowledge about their behavior and potential adaptation to different climate conditions.

The reuse of wastewater in irrigation: contribution to the sustainability in water resource management facing climate change

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Abstract

The reasons for wastewater reuse practices are mainly due to the current and future scarcity of water resources and the need for river protection. The scarcity of increasingly marked water resources, resulting from climate change as consequence of population growth and socio-economic development, highlights the need for sustainable management of water resources, in with re-use is a particularly important strategy/component. The water resources of a region depend on its climate (temperature, evapotranspiration) as well as water from the river basins. In this way, the availability of these is not constant throughout the year, reflecting the climatic seasonality. The water needs for human activities are also not constant depending essentially on population growth, industrial development and, with a major impact, on agricultural use. These situations generate imbalances between the need and availability of water, which can be severe mainly in years of precipitation shortages. The degradation of the quality of some natural waters, resulting from insufficient pollutant control, drought and flooded, announced as likely consequences of climate change, introduce strong limitations to water use, both due to quantity and quality. Water management must increasingly apply the concept of sustainability to optimize the benefits of current use, without compromise the same possibility for future generations. Technology may answer some questions, including the construction of dams or the desalination of seawater, but alone is not sufficient to ensure the sustainability of these resources. It is therefore necessary to use water resources more efficiently, which involves necessarily its reuse for irrigation, while allowing to supply some nutrients to soil and plants, avoiding their direct discharge into the water environment, reducing the risk of associated pollution.

Assessment of the ecotoxicological effects of copper for terrestrial organisms in different vineyard soils

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Abstract

Copper-derived plant protection products have been intensively used in vineyards since the 19th century. Due to its low mobility, Cu tends to accumulate in the upper soil layers, after spray applications, rainfall removal from the vines, and deposition of the senescent leaves. According to EU reports, vines are among the crops that concentrate the highest amount of Cu in soils, which may pose serious environmental risks, affecting non-target biota with key role in soil functions. However, when assessing its impacts, not only total Cu concentrations in soils should be considered, but also its bioavailability, which is strongly affected by the soil properties and aging processes. Therefore, to assess the potential impacts of Cu accumulation for terrestrial organisms, ten vineyard soils with different properties were spiked in the laboratory with different Cu concentrations (from 0 to 1000 mg kg⁻¹) using Bordeaux mixture. After one month of incubation, reproduction assays with the earthworm *Eisenia fetida* and the collembola species *Folsomia candida* (OECD 222 and 232, respectively) were performed, as well as a seedling emergence and growth test with the cover crop species *Medicago sativa* (OECD208). In order to assess the potential for bioaccumulation of Cu residues in these soils, the levels of this element in the earthworm and in plant tissues were also determined. At the end, it was possible to understand which are the soil properties that account for a great availability of Cu and for subsequent effects to terrestrial organisms.

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Seasonality of rainfall erosivity and soil loss extremes and variability in Douro vineyard plots

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Abstract

Seasonality and frequency of erosive rainfalls largely affects runoff and soil loss and should drive timing of soil conservation practices and farm operations, an important issue for reducing on-site and off-site erosion impacts in vineyards.

This study aims at exploring seasonality and frequency of rainfall erosivity and their relation to the erosional response of vineyard plots located in the Douro Wine Region. Data used in the study are the 10-year records from 5 plots at Quinta de Santa Bárbara, Pinhão (rainfall, runoff, soil loss, vine phenology and tillage operations). EI30 (reference rainfall erosivity index) was computed for different rainfall intensity and height thresholds. IDF curves were derived for durations from 5 min to 24h. Frequency analysis of rainfall height, intensity and erosivity were performed on annual and seasonal basis. Rainfall erosivity is the main factor explaining plots erosional response. From all computed indexes, the best performing was EI30m, calculated with all rains (no threshold), relating at event level in a power function with soil loss ($r=0.713$). EI30m (796 MJ ha⁻¹ mm h⁻¹ annual average) correlated very well with the original EI30, calculated for events above defined rainfall height threshold ($r=0.997$). Seasonality affected IDF curves parameters, higher intensity being found in summer than in winter rains for durations shorter than 3 hours. Out of 167, 3 extreme erosion events accounted for $\frac{3}{4}$ of the total soil loss in 10 years and resulted from rainfalls with return periods from 20 to 100 years. Annual average soil loss has a typical negative exponential relationship with plots vegetation cover. However, plot cover provided by plantation schemes and practices in Douro Wine Region may result insufficient to limit to tolerable rates soil losses triggered by high erosivity rainfalls, using actual vegetation cover management practices alone.

Cytogenomic effects of kaolin in ‘Touriga Nacional’ and ‘Touriga Franca’ under summer stress

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Abstract

Touriga Franca (TF) and Touriga Nacional (TN) are wine-producing varieties traditionally cultivated at ‘Douro Superior’ (NE Portugal). During the summer, these vineyards experience extreme climatic conditions like high radiation and temperature, and water stress that ultimately generate oxidative stress compromising productivity and quality. The kaolin (KL) application in grapevine reduces the leaf temperature and improves its photosynthesis and wine quality. However, its effects at the cytogenomic level are unknown. In this work, TF and TN leaves were collected in control (untreated) and KL-treated plants at ‘Quinta do Orgal’ (Douro Superior) during the summers of 2016 and 2017, for further analysis of the mitotic cell cycle and expression of the genes HSP17.9, VvCYCA3, VvICK5, APX1, CAT and MDHAR using quantitative real-time PCR (qPCR). The control plants showed cell cycle arresting in prophase. These data were corroborated by the relative expression of the VvCYCA3 and VvICK5 genes (involved in cell cycle regulation). Heat stress alone halts cell division but the decrease of leaf temperature by KL, confirmed by the down-regulation of the HSP17.9A gene, allowed the cell cycle to progress in KL-treated plants. Also, the KL-treated plants showed up-regulation of the APX1, CAT and/or MDHAR genes encoding for antioxidant enzymes, suggesting the improvement of antioxidant ability. Both cytogenetic and relative gene expression differed significantly ($p < 0.05$) between varieties, treatments, years, sampling dates and their interactions. The KL treatment was more effective in TN and in the summer of 2017 that showed lower temperatures than 2016.

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Evaluation of bud fruitfulness and morphometric characterization of inflorescences and bunches in three grapevine varieties grown in NW Portugal

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Abstract

Bud fruitfulness, number of bunches per grapevine and berry number per bunch are parameters that determine grapevines' yield. Therefore, bud fruitfulness (before budburst) and morphometric characteristics of inflorescences and bunches in three *Vitisvinifera* L. white varieties (Alvarinho, Fernão-Pires and Loureiro) were assessed into vineyards located at the Vinho Verde Demarcated Region (NW Portugal), during two consecutive seasons. Different methodologies were tested based on anatomical bud analysis (bud dissection and histological observations), forcing bud growth under controlled environmental conditions, and determinations of the main parameters of rachis inflorescences and bunches at different phenological stages. The results showed a variation in the studied variables, mainly for bud fruitfulness, carbohydrates reserve content, and weight and number of berries per bunch. In all varieties, we observed an increase in bud fruitfulness parameters and carbohydrates reserves, from 2017 to 2018, as a result environmental conditions during the previous season. Significant allometric relationships were observed for weight, volume and number of flowers and berries in the three varieties. The dimensions of the rachis and the lengths of the primary insertions of bunches were positively correlated. A strong correlation was also observed between the wing and the width of the bunch for Alvarinho and Fernão-Pires varieties. Berry size differed between vineyards and varieties, while the number of seeds per berry proved to be a varietal attribute. In this way, the assessment of bud fruitfulness and morphometric characteristics of inflorescences and bunches can contribute to the understanding of varietal performance over the growing season and in the yield.

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Modelling vine water stress during a critical period and potential yield reduction rate in European wine regions: a retrospective analysis

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Abstract

Most European vineyards are managed under trained conditions, where seasonal water deficit has become increasingly important. The flowering-veraison phenophase represents an important period for vine response to water stress, which is seldomly thoroughly evaluated. Therefore, we aim to quantify the flowering-veraison on water stress levels using Crop Water Stress Indicator (CWSI) over 1986–2015 for important European wine regions and to assess the respective potential Yield Loss Rate (YLR). Additionally, we also investigate whether an advanced flowering-veraison phase may help to alleviate the water stress with improved yield. A process-based grapevine model STICS is employed, which has been extensively calibrated for flowering and veraison on stages using observed data at 38 locations with 10 different grapevine varieties. Subsequently, the model is being implemented at the regional level, considering site-specific calibration results and gridded climate and soil datasets. The findings suggest wine regions with stronger flowering-veraison CWSI tend to have higher potential YLR. However, contrasting patterns are found between wine regions in France-Germany-Luxembourg and Italy-Portugal-Spain. The former tends to have slight-to moderate drought conditions (CWSI < 0.5) and a negligible-to-moderate YLR (< 30%), whereas the latter possesses severe-to-extreme CWSI (> 0.5) and substantial YLR (> 40%). Wine regions prone to a high drought risk (CWSI > 0.75) are also identified, which are concentrated in southern Mediterranean Europe. An advanced flowering-veraison phase may have benefited from cooler temperatures and a higher fraction of spring precipitation in wine regions of Italy-Portugal-Spain, resulting in alleviated CWSI and moderate reductions of YLR. For those of France-Germany-Luxembourg, this can have reduced flowering-veraison precipitation, but prevalent alleviations of YLR are also found, possibly because of shifted phase towards a cooler growing season with reduced evaporative demands. Overall, such a retrospective analysis might provide new insights towards better management of seasonal water deficit for conventionally vulnerable Mediterranean wine regions, but also relatively cooler and wetter Central European regions.

Progress and perspectives of grapevine clonal selection in the Primorska winegrowing region in Slovenia

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Abstract

Slovenia is a traditional winegrowing country with 30-year permanent program of grapevine selection taking care of own scions, rootstocks, and grafts production. Until today, we have selected and certified 39 clones of 16 different grapevine varieties. An important characteristic of Slovenian viticulture is also a large number of local and indigenous grapevine varieties, which have been kept mostly in Primorska region, in terraced vineyards on steep slopes with inclinations over than 30%. Preservation of local varieties is important for biodiversity, which is one of the principles of agroecology and belongs to a set of innovative approaches in sustainable viticulture. Regarding the local varieties, only a few clones have been obtained and registered yet what become a problem, due to the increase of interests for wines from local varieties. Therefore, the clonal selection is nowadays more focused on 'Malvazija', 'Refošk', 'Sauvignon vert' and 'Zelen' varieties, which also show higher adaptation to the now environmental conditions and climate changes. At the moment, we can boast with 4 new clonal candidates of 'Malvazija' variety, characterized by different growth and yield potential, as well as by grape and wine qualitative parameters. Key Words: grapevine, clonal selection, clone, local varieties, sustainable viticulture.

The enhancement of the viticulture in Valcamonica region through a zoning study

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Abstract

Viticulture plays a crucial role in some Alpine valleys of Lombardy (Italy). Indeed, in addition to wine production, it takes part to the safeguarding and maintenance of typical landscapes; to the preservation of high-slope areas from hydrogeological risks; to the tourism development linked to the food and wine. For these reasons, it is important to enhance the wineries in these areas, through studies to optimize their agronomic and oenological management, profitability and economic sustainability. The viticultural zoning can be a useful tool to reach these goals. In Valcamonica (Lombardy, Italy) grapevine was cultivated since the roman age. After a drastic decrease of cultivated area in the '80 of the last century, during the last years, viticulture is increasing its importance in the local economy, with a real interest to understand the potential aptitudes of the different areas. In this context, a three-years viticultural zoning study of the valley started in 2019. First, pedo-climatic characteristics and their spatial distribution in the valley was considered through analysis of meteorological series and geological and topographic data. This study allowed to a preliminary division of the valley into homogeneous unit. In each of them, representative vineyards were chosen, considering Merlot and Manzoni bianco, the main representative varieties present in the valley. In these fields, in each year, phenology over the season was collected. Furthermore, at harvest quality and productivity parameters was analysed. Finally, grapes from each vineyard were separately vinified. The wines obtained was tasted by an expert panel. Results shows an interesting variability in environmental condition between the cultivated areas of the valley, with difference in timing of the phenology and harvest, in the quality of the grapes and in the sensory characteristics of wines. Finally, agronomic and oenological guidelines were written to optimize specific wine aptitudes of each area.

Effect of pesticides application on soil quality: a comparison of two vineyards management systems

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Abstract

Organic and integrated pest management (IPM) systems are being increasingly implemented. They differ in pesticide use policies: while in IPM the focus is on reducing the use of pesticides, in organic farming the use of synthetic organic pesticides isn't allowed. Thus, independently of the production mode, pesticides are used and therefore, in both cases, negative impacts to the environment may occur. One of the reasons is the high amount of copper used in organic viticulture, which accumulates in soils, but that can also reach the adjacent aquatic systems. This issue is of special concern in vineyards established in mountains such as in the Douro region, with steep slopes which are more prone to erosion and subsequent dispersion of contaminants. To understand the possible benefits of organic vineyards, when compared to IPM, three vineyards under two different farming systems were chosen in the Douro Demarcated Region. The sampling of soils took place in two periods, one during the application of phytosanitary products and the other six months after. To evaluate the effects of direct exposure of soil fauna to products applied, and the consequences of their leaching, several ecotoxicological assays were carried out using a battery of soil and aquatic test organisms. Results show the absence of toxicity of soils and soil elutriates to test organisms, in both sampling periods, while in vineyards under IPM, toxicity is shown, to some extent. Notwithstanding, results also show an ability of soils to recover, since outside the application period potential adverse effects of vineyard samples aren't significantly different between both management systems.

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Heroic viticulture and terraced landscapes' characterization: the case study of Aosta Valley (Italy)

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Abstract

The “heroic” attribute is recognized to viticulture carried out in particular conditions, in order to underline the great efforts that requires in terms of physical works and investments of resources and time. In Italy an Inter-ministerial Decree (nr. 6899 – 30 June 2020) fixed for the first time at a regulatory level the context’s characteristic for defining a heroic vineyard: higher altitude than 500 meters above sea level; higher slope than 30%; cultivation on terraces; cultivation on small islands. Viticulture terraces strongly characterize Aosta Valley, that is one of the Italian Regions involved in a European project – Italy and Switzerland – called InTerraced_net(EU Interreg funding, 2018). In this context the aim of the research was the assessment of terraced landscapes using a holistic approach. Construction types, features and problems were detected with field inspections using a survey form. Winegrowers’ point of view was investigated with an online anonymous questionnaire. Participative analyses were performed with field inspections and cartographic elaborations using QGIS 3.16.2 Hannover. Results showed that AostaValley’s vineyards are characterized by dry stone walls in the northern and southern part of the Region and by ridge terraces in the middle. The main historical landmarks are related to the vine’s breeding systems. Low pergolas supported by stone elements and made up of larch poles are characteristic of the northern part, while high pergolas built with chestnut poles have been detected in lower valley. These elements showed an important role from the perceptive point of view. Seasons underlined different interesting elements in terms of perception: vegetative mass during spring and summer, autumnal colors and the presence of the snow that highlights terraces in winter. Study allowed to develop a scientific integrated approach for the assessment of the heroic viticulture terraced landscapes aimed at identifying strategies and actions useful for their enhancement.

Wine producers in the Douro Demarcated Region: a prospective analysis

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Abstract

In order to define and support policy measures aimed at the sustainability of wine production in the Douro Demarcated Region (DDR), this study aimed to survey and characterise who produces wine in the DDR, particularly those constituting the Port and Douro wine value chains. To achieve these objectives, a quantitative, exploratory approach was used, based upon bibliographical data from 2009 to 2020. This analysis focused on viticultural production conditions, with particular emphasis being placed on the socioeconomic, environmental, and technological dynamics that influence its sustainability. The results indicate that the DDR has experienced a concentration of land in larger farms, along with increased land as measured by Agricultural Area Utilized (AAU). Most of the AAU is occupied by permanent crops, with vineyards being the most representative. Farms are characterised by the use of family labour, albeit accompanied by the increased use of machinery. Most of those managing farms are over 65 years old and possess only basic levels of education. The family farm population has decreased, as has the population resident in the DDR. Though most units active in viticulture in the DDR are micro enterprises, it is the medium-sized firms, albeit fewer in number, which employ the most labour and generate the most turnover. The analysis of economic indicators suggests that firms are in a relatively stable economic situation. The data collected in this study has re-emphasized the DDR importance, Portugal's second largest wine-growing region in terms of area, to the Portuguese economy and society, affect that needs to be taken into consideration if appropriate policy measures are to be defined with a view to enhancing the sustainability of wine production.

The recovery of the traditional vineyards of Santa Maria Island (Azores – Portugal): preliminary results of the stakeholders' views

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Abstract

The vineyards of the Santa Maria Island use techniques of terraces divided into parcels and sustained by dry stone walls. These vineyards are cultural landscapes located at the cliffs of the bays. The cultivation dates back to the settlement. It has been partly abandoned causing the ruining of the walls and the growing of weeds. In 2018, a project for the recovery gathered the regional and local government, the University of Azores and a company. The main aim was the recovery of the vineyards according to the traditional use (e.g. reconstruction of walls; new plants for wine production; wine tourism initiatives). Consensus and involvement of the stakeholders are pre-conditions for recovering a landscape characterised by strong physical constraints (e.g. steep slopes). The purpose of this study is to analyse the motivations and expectations of the different stakeholders and to compare them with the guidelines of the recovery programs. The contents of the programs and policies and the exploratory interviews to stakeholders were analysed with software for qualitative research. It is a preliminary analysis and part of a doctorate in Geography at IGOT-UL. The interviews showed a comprehensive knowledge of the problems and solutions for the viticulture and the maintenance of the landscape. Therefore the results presented broader possibilities to the recovery which go beyond the undertaken measures. The production and economy of the vineyards is a key feature. Nevertheless a more open approach can be taken for achieving resilience. The support actions to the viticulture can be better aligned with the views and needs of the stakeholders. It seems relevant to take into consideration other uses and/or functions: some already into practice (e.g. traditional orchards) and some new (e.g. vineyards as part of the walking trails). Nevertheless all actions should respect a landscape located on a very delicate environment.

Herbicide-free understock cultivation in terraced steep slope vineyards

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Abstract

The herbicide most commonly used in viticulture, called glyphosat, will lose its approval in Germany at the end of 2023. Especially in terraced steep slope vineyards, it is often difficult to find the appropriate alternative. There are a lot of challenges, such as a small cane spacing, small distance between the vine row and many more. Our aim was to find a solution for vintners to work in terraced steep slope vineyards without herbicide, in the mechanical way. Four different mechanical alternatives were tested. The over-row stick brush, a string mower, a rotary harrow and the most common variant, the rotary hoe. The cultivation with the over-row device had shown much better results, because they work the inside and outside from the vineyard line. We also made some tests with greening and soil covering under the vines. The combination of several different understock devices or the combination of understock devices with subsequent greening or covering are quite reasonable.

The effect of winery waste compost and biochar on Douro vineyards production

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Abstract

The effects of biochar and winery waste compost were assessed on vineyards production in order to return winery waste into resources through a circular process. With this aim, a 2-year field experiment was set up with 5 treatments including: (i) 5 t ha⁻¹ biochar (B5), (ii) 10 t ha⁻¹ biochar (B10), (iii) 30 t ha⁻¹ compost (C30), (iv) 30 t ha⁻¹ compost and 5 t ha⁻¹ biochar (B5C30), and (v) a control treatment without soil amendments (T0). The compost was produced with winery sludge and grape stalks at a mixing rate 2:1 (sludge: stalks, w/w). In the year of application, N content was similar in all treatments except for B5C30. However, in the second year, N content increased for C30 or T0 compared to B5. In both years P content was similar in all treatments except for occasional differences. Potassium content increased in fertilized treatments compared to control. Conversely, Ca and Mg content decreased in fertilized treatments compared to control except for Ca in the second year. In this context, the clusters weight decreased with biochar application compared to control and the inclusion of biochar in the compost also resulted in clusters weight decrease. The winery waste compost showed positive effects as soil fertilizer. Nevertheless, further long term field experiments are needed to clarify the role of biochar on vineyard production.

THEMATIC AREA 2

**Improving agronomic practices
through new technologies**

Influence of pruning system and deficit irrigation on grapevine physiology, yield and grape quality of cv. Sousão (*Vitis vinifera* L.) growing under Mediterranean conditions.

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Abstract

Different strategies are currently being sought to mitigate the effects of grapevine summer water stress. Regulated Deficit Irrigation (RDI) is a strategy that has been successfully adapted. Also, some pruning systems have been identified as being capable of influence vine water balance.

The aim of this work was to evaluate the effect of two RDI strategies and two pruning systems on grapevine physiology, yield and grape quality of Sousão variety grown under Mediterranean conditions. This study was conducted in an organic vineyard located in northeastern Portugal (41°31'N; 7°5'W; 326 m a.s.l.), planted in 2011 with 1103 P rootstock. The pruning systems, single Cordon and single Guyot, were established in 2013. In 2019 and 2020, three irrigation treatments were implemented: a full irrigation control FI (100% ETc) and two deficit irrigations treatments, RDI 25 (25% ETc) and RDI 50 (50% of ETc).

During growing season, grapevine water status and physiological parameters were monitored. At harvest, yield, yield components and grape composition were evaluated and analysed.

The results showed that the vines under a RDI regime presented leaf water potential values significantly lower than the vines under FI, in both pruning systems. Therefore, the grapevine physiological performance was affected by decreasing its stomatal conductance, transpiration and photosynthesis. However, the lower physiological performance did not significantly affect yield. Regarding the grape composition, no significant differences were observed in total soluble solids, and total acidity. However, there was an increase in anthocyanins and phenolic compounds in grapes with less irrigation.

Effects of induced water stress in the mitotic cell cycle of Touriga Franca, Touriga Nacional and Viosinho plants grown *in vitro*

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Abstract

Viticulture has been affected by climate change. Long-term adaptation strategies can include the selection, use and/or improvement of varieties more tolerant to abiotic stresses.

We aimed to evaluate the effects of induced water stress in Touriga Franca (TF), Touriga Nacional (TN) and Viosinho plants cultured *in vitro*, through the inclusion of 10% and 20% polyethylene glycol (PEG) in the culture medium. Vegetative development parameters were monitored for four weeks and the leaf mitotic cell cycle was analysed.

Viosinho showed the highest mean values of *in vitro* development parameters (nodes, shoots and leaves number), differing significantly from the other varieties. Under 20% PEG, Viosinho and TN showed the highest mean values of *in vitro* development parameters, showing tolerance to severe water stress. The analysis of the leaf mitotic cell cycle revealed anomalies in interphase (irregularly shaped nucleoli and micronucleoli) and mitotic cells. Most of the mitotic cells were in prophase, suggesting cell cycle arresting in response to water stress. Similar results were found previously in grapevine and other plant species under different abiotic stresses. The average mitotic index (MI) and percentage of dividing cells with anomalies (%DCA) differed significantly among varieties, treatments and their interaction. Despite the high mean values of MI in all varieties, the %DCA was significantly lower in TN, 10% PEG and in the TN×10% PEG and TN × 20% PEG interactions. Generally, the %DCA increased with the PEG concentration, namely in Viosinho. The combination of all results suggested the TN variety as the most tolerant to moderate and severe water stress. The approaches followed in this work can be applied to different varieties and abiotic stresses constituting a useful tool for selection and further use and/or genetic improvement of *Vitis vinifera* varieties more tolerant to abiotic stress, which in combination with appropriate practices can ensure a sustainable viticulture.

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Steep-Slope Viticulture and Climate Change: Threats, Monitoring, Sustainable Management

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Abstract

Steep-slope vineyards landscapes cultivated often with terracing practice could represent historical heritages and cultural ecosystem services for some regions. For this reason, they deserve to be protected. Nowadays, such areas are under threat because of global environmental changes. The increase of frequency of intense meteorological events, in addition to land abandonment, lack of structural maintenance, and in some cases, unsuitable agronomic practices, are exposing steep-slope agricultural landscapes to severe degradation (e.g. soil erosion, landslides). Therefore, it is necessary to find solutions for the mitigation of hydrogeological risk and to respond in a well-prepared way to the possible future critical scenarios, and to adopt a series of sustainable strategies with the purpose to preserve the ecosystems but also tradition and people. Thanks to the recent technological advances in the topographic survey (e.g., structure from motion photogrammetry using drones), it is possible to perform high-resolution digital terrain analysis to provide essential information for decision-makers to plan sustainable interventions. Moreover, it is possible to tackle the problem of hydrogeological risk from a unique and privileged perspective: that of prevention.

Application of a mulch to prevent weed growth in the vineyard comprised of an organic substrate produced from grape stems and waste activated winery sludge combined with vine shoots

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Abstract

The destemming of grapes is increasingly adopted in the winemaking process, to avoid the solubilization of compounds with herbaceous or vegetable characters which could have a negative impact on wine aroma and flavor qualities. As a result, up to 12% of the grape volume received at the winery should, almost immediately, be eliminated. However, the correct handling of grape stems proved to constitute an important challenge from the technological point of view.

During the last three decades, several scientific studies focused on this subject, proposing several solutions that go from the utilization of the stems as biomass for energy production, to their valorization through advanced industrial processes aiming to extract specialty raw materials for food, cosmetic and pharmaceutical industries. Recently, we were able to elucidate the biological mechanisms involved in the treatment of this material through efficient processes of mesophilic composting (20 % volume reduction, with only a fraction of the traditional CO₂ emission). In this process, another residue known to be hard to eliminate, the waste activated sludge produced by the winery wastewater treatment plants, is co-composted with grape stems, in order to obtain a stable organic substrate in just 2 months, regardless of weather conditions, and with a germination index of 161%. In the present study, we will discuss the application of this material combined with vine shoots as a mulch to prevent weed growth and to retain moisture in the vineyard.

Taking the lab to the vine: increasing value through real-time autonomous control of grape ripening in labor-intensive vineyards

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Abstract

The wine sector is evolving in an increasingly competitive international scenario characterized by the irruption of new producing countries with innovative strategies in production and trade, allowing them to occupy growing shares in the global wine market. Douro Wine Region, a UNESCO World Heritage Centre, with its terraced vineyards set in steep-slopes and labor-intensive viticulture, where manual data sampling is insufficient due to unaffordable costs, is seeking for cost-efficient strategies to a more precise field monitoring to grant repeatability strategies. Several approaches of in-field monitoring systems have recently been developed, such as plant-based, proximal robot-mounted and remote, drone, airborne and satellite sensors for vineyard applications. In this work we present a project to develop a fully integrated, small, low-cost, standalone smart system used for grape maturation monitoring, the i-GRAPE sensor. Conventional grape maturation state assessment methodologies rely on wet-chemistry analysis of the grape composition in the laboratory. These reliable methods are hampered by limitations in sample numbers, the distance to field and time gap between sample collection and analytical results. Furthermore, they are time-consuming, labor-intensive, and generate significant amounts of chemical waste, besides reporting discrete time points, usually at weekly intervals. Over the last decade, commercial solutions became available for portable, non-destructive grape analysis and semi-portable, destructive devices providing in-field measurements. Those instruments offer a measure of chlorophyll and polyphenols through reflectance and fluorescence spectrometry, however, require human operation for data acquisition and are not stand alone.

Project i-GRAPE proposes to bring the “lab to the vine”, by continuously monitoring grape maturation through a novel autonomous sensor towards a more precise grape maturation sampling to gain accuracy and better manage its quality potential. It will reduce the workload and will provide a better representation of grape ripening in highly heterogeneous steep-slope mountain vineyards, while avoiding waste («green chemistry»). This project has a long-term view to support sustainability for grape growers and provide winemakers with better knowledge on the grapes they use to make wine.

Climate, soils and topography of the Douro Winemaking region: a clustering approach

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Abstract

The Douro Demarcated Region (DDR) is one of the most important mountain winemaking regions in the world. Viticulture is historically and culturally tied to the DDR, having a strong impact on the local economy. This mountainous area, characterized by the slopes of the Douro Valley, offers a wide range of environmental features for grapevines.

Different climates, soil characteristics, topographic features, varieties and management practices account for the DDR terroir, resulting in the particularity of the wines produced. In the present study, an assessment of the homogeneous viticultural zones is proposed for the DDR, by integrating different terroir elements (thermal, hydric, soils, topography and vegetation), using modern high resolution datasets (1 km) and a large number of indicators. A multivariate zoning was assessed through a principal component analysis and a subsequent clustering approach. A geospatial assessment of the DDR terroir was also performed separately for each type of vegetation. The interrelationships of the different terroir elements that exist at a given location, were also innovatively evaluated. The zoning may stimulate a more suitable selection of vineyard sites, or the selection of more adapted varieties and rootstocks.

Additionally, this zoning may promote the adoption of proper viticultural practices and management planning. Subsequently to assessing the current terroir conditions, possible expansion zones within the DDR were also evaluated. The present study may also be used as an archetypal methodology that can be applied to other winemaking regions worldwide.

This study was supported by the Clim4Vitis project – “Climate change impact mitigation for European viticulture: knowledge transfer for an integrated approach”, funded by European Union’s Horizon 2020 Research and Innovation Programme, under grant agreement n° 810176. This work was also supported by National Funds by FCT - Portuguese Foundation for Science and Technology, under the project UID/AGR/04033/2019. FCT contract CEECIND/00447/2017 is acknowledged.

How to promote a sustainable weed management strategy in steep slopes vineyards?

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Abstract

In steep slope viticulture, the existence of vegetation cover is of utmost importance in order to reduce the risk of erosion. However, under Mediterranean conditions, there is a need for applying cost-effective control strategies in areas where vegetation cover may compete with vineyards for soil and/or water resources during the growing season. In Douro Demarcated Region (DDR), due to climate change impacts, the application of long-term chemical and/or mechanical strategies, combined with herbicide resistance phenomena, spontaneous vegetation has evolved and adapted to current conditions (lack of water, poor soils), representing nowadays a big challenge for farmers. In steep slope vineyards, mechanisation rely on very specific equipment's and technical options for floor management are limited so herbicides are still used in a significant surface. Considering the growing concerns on the impacts of pesticide application and the specificities of the DDR, ADVID has been promoting an environmentally sustainable control strategy for the Douro wine sector. Trying to find alternatives to chemical control, several wine companies have been pioneering the implementation of strategies to diversify vineyard landscape by promoting or preserving native ground cover, native hedges, non-crop habitats nearby vineyards, resulting in a significant reduction in the use of herbicides on their farms. A sustainable weed control strategy based on the combination of preventive, mechanical, and chemical methods is briefly described in the Handbook "Different strategies for weed control in hillside viticulture" published by ADVID in 2019. Moreover, a survey was conducted about costs related with weed management on different technical itineraries performed in several types of vineyards (traditional systems vs mechanized systems), and under different production systems (integrated vs organic production). Preliminary results of this survey point out that the weed management strategies implemented in steep-slope viticulture presents specific difficulties resulting in high to very high costs.

Vineyard differential management zones using UAV in DO Ribeira Sacra – Spain

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Abstract

The use of drones in vineyard areas with a steep slope and difficult access allows obtaining information on the vineyard vegetative state at any time of the year in which the climatic conditions are favorable, facilitating the differential management. The manual performance in the vineyard of most tasks creates the necessity to reduce the use of inputs to improve its sustainability, reducing costs. The objective of the study is to assess the vegetative differences in two white varieties (Godello and Blanco Lexítimo) to facilitate the vineyard differential management zones and improve the yields. The study vineyard has 4.6 hectares located in the Ribeira Sacra DO (Galicia - Spain). During the years 2018-2019, seven plants per row in two and four terraces, of Godello and Blanco Lexítimo, respectively, were set for monitoring. The average production per plant and the must basic characteristics obtained at each terraces have been analyzed. In 2019, two drone flights with multirrotor were made, coinciding with flowering and veraison, using a thermal and a multispectral camera. Vegetation indices (NDVI and NDRE) have been determined to define differential management areas, relating them to the productive parameters measured during the harvest. The results of the vegetation indices have shown a high vigor for Godello in all terraces, compared to the results for the Blanco Lexítimo. These results coincide with the greater production of the Godello in the year 2019 (1.73 kg/plant) compared to the 0.85 kg/plant of Blanco Lexítimo. However, these results don't coincide with the 2018 season, where a slightly higher production was obtained for Blanco Lexítimo (3.46 kg/plant) compared to Godello (2.93 kg/plant). The drone allows to obtain the spatial variability in the field during flowering and a forecast of the production from the veraison flight, being therefore a management tool to improve the profitability of mountain vineyards.

Treatment of winery wastewater by combination of organic coagulants powders and photocatalytic processes

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Abstract

The production of wine is one of the main agro-industries in the world, which generates a large volume of winery wastewater (WW). An initial analysis of a red and white WW revealed a low pH (4.0) and a high content of biological oxygen demand, chemical oxygen demand (COD), total polyphenols, turbidity and total suspended solids. In order to treat these recalcitrant compounds a new type of organic coagulants powders (OCP) were developed based on plants such as *Vitis vinifera* L., *Daucus carota* L., *Dactylis glomerata* L., *Festuca ampla* Hack., and *Tanacetum vulgare* L. OCP's were used as coagulants to treat the WW before performance of photo-Fenton process. The objective of this work was to: 1) produce, characterize and evaluate OCP's as coagulant agents in comparison to ferric chloride; 2) evaluate the combined effect of coagulation with photo-Fenton oxidation in a KPS/H₂O₂/UV/Fe²⁺ system; 3) evaluate the separation of red and white WW on TOC removal and operational cost in final treatment. The morphology and functional groups present in OCP were investigated by scanning electron microscope (SEM) and Fourier transform infrared (FTIR) spectroscopy. The photocatalytic experiments were performed in a batch cylindrical photoreactor equipped with a UV-C low pressure mercury vapour lamp. Coagulation of WW by OCP's such as *Vitis vinifera* L. had a high removal of turbidity, TSS and total polyphenols of red WW (94.6, 92.5 and 80.9%) regarding ferric chloride (94.6, 89.5 and 0.5%). The oxidation process was observed to be very efficient in the TOC removal of red and white WW (91.2 and 96.8%). The combination of coagulation (OCP) and oxidation reaches a TOC and COD removal higher than 90%, making the final results in accordance to the legislative values by Portuguese Decree Law nº 236/98, with low costs (0.639 and 0.443 €/m³). In conclusion OCP's are environmentally safer and efficient in combination with oxidation process on WW treatment.

Thermal images to estimate vineyard water status in a temperate climate area

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Abstract

The hydric state of the vineyard is currently a very important concept that directly affects the production and quality of the grapes. The use of thermal images, is the answer to an efficient system that allows to control these variables and improve production, obtaining higher quality wines, as well as making better use of resources such as water. The present study shows an analysis methodology for the water state of 10-hectares vineyard planted with the *Vitis vinifera* cv variety. Albariño, using thermal images of high spatial resolution for the 2019 campaign, with an unmanned aerial vehicle (UAV), in flowering and veraison. In this way, the analysis of the thermography allows us to know the hydric state of the vineyard, in order to face the evapotranspiration demand of the vine in its most critical moment, between flowering and the veraison of the cluster. The most used method to know the water state of the plants is the stem water potential, which is determined by measuring with a pressure chamber at sampling points throughout the plot, at solar noon. For this reason, it is interesting to analyze the temperature of the vegetation and the Crop Water Stress Index (CWSI) a more effective method of determining the vineyard's water state in big areas at a reasonable cost and without damaging plant material. Therefore, stem water potential data, have been taken at 32 points spread over a 30*30m mesh throughout the plot, to evaluate the response of thermal images obtained with the UAV. According to the results obtained, the use of thermal images is a good index of the hydric state of the vegetation and a useful tool when planning the irrigation of it in large areas, establishing different irrigation strategies depending on the areas of the vineyard that they have a higher demand for water.

No one is left behind: how Sogrape promotes sustainable viticulture in Portugal's Douro Valley

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Abstract

SOGRAPE, a family-owned wine company, developed a Global Sustainability Program strongly committed with the United Nations' Sustainable Development Goals. Novel plant protection strategies minimizing negative environmental impacts are fundamental for sustainable viticulture. In this sense, two projects are underway in SOGRAPE's Quinta do Seixo and Quinta do Sairrão, two properties located in Cima Corgo central sub-region of the Douro valley. Douro viticulture has unique microclimates, created by the rugged landscape and the steep slopes. Vineyards possessing different topography, altitude and slope aspect are subjects of study in these projects. Project NOVATERRA (funded by EU's Horizon 2020) aims to improve the sustainability of viticulture by integrating new plant protection products (PPPs) of natural origin, biodiversity conservation, precision agriculture, robotics, and integrated soil and crop management strategies. This project is based in a practical and integrative approach, promoting multivariate case studies, in real scale trials executed by SOGRAPE to maximize adoption of any successful solutions obtained from case studies. Project COPPEREPLACE (funded by EU's Interreg Sudoeste) aims to reduce copper use in vineyards. Excessive exposure to copper accumulation in the soil causes problems to the environment and human health. The project trials strategies to reduce or replace the use of copper in vineyards with new PPPs, while evaluating strategies to remediate copper-contaminated soils. All vineyards owned by SOGRAPE are certified sustainable (Integrated Production) and have automated weather stations providing data to support decision making in protecting vineyards from disease while reducing environmental impact. The novel techniques gauged in these two projects work for the same goal of paving the way towards increasingly sustainable agriculture, combined into an integrated vine protection strategy. Results will be widely disseminated in open events and communications as well as through national and international networks, fulfilling SOGRAPE's pledge to contribute for knowledge dissemination among its grape suppliers.

Mechanical harvesting innovation in steep slope vineyards: Douro region case study

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Abstract

The total vineyards in the Douro is 44,000 hectares and about 44% of the total vineyard area is laid out on slopes with gradients above 30%, a proportion which rises to 71% if one considers the vineyard area classified as a World Heritage. Furthermore, the Douro accounts for the world's highest percentage of mountainside vineyards (52% of the total). Despite developments in recent decades in this sort of machinery, there is a shortage of solutions which address the mountainside vineyards in terms of steepness variability within a given parcel, accessibility, and - above all - systematic operability on earth-banked terraces. At the same time, the Douro has been experiencing a declining population for over 15 years. We face a considerable challenge if there aren't enough people to bring the grapes into the winery at harvest time. From 2014 to 2018 Symington led a ProDER Cooperation for Innovation Project, with the participation of a technical partner from Germany. The principal objective of this project is the development/adaptation of harvesting machinery adapted to mountainside vineyards which allow gains in efficiency in mechanical harvesting operations and the preservation of the quality of the grapes. The project entailed four Work Packages: i) evaluation of the interfacing with vineyard layouts compatible with mechanical operations, ii) development and adaptation of machinery for grape harvesting in terraces, iii) evaluation of the viticulture and winemaking impacts; iv) communication and results dissemination. There are still challenges to overcome, including adapting some of our vineyards to accommodate the harvester, but the 2019 harvest was the 4th year of trials with the harvester, which performed well on terraces at several of our field experimental plots and largely exceeded expectations with values of 13 ton/day. Field efficiency increased from 45% in 2017 to 65% in 2021. Guidelines to adapt vineyards to the new equipment were also drawn up.

Kaolin application effects in Touriga-Franca leaf physiology, photoprotection responses and berry ripening under a changing climate

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Abstract

The climate scenarios for the upcoming decades point to shifts in the agricultural production patterns worldwide, which may impair natural grapevine mechanisms due to the combined effects of abiotic stresses, which promoted the study of adaptation strategies in viticulture. In this study, we applied kaolin (5%) in two commercial vineyards in the Douro and Alentejo regions, aiming to understand its effects on the leaf physiological performance, pigments content, and fruit hormonal levels in the variety Touriga-Franca, throughout the summer season of 2017 and 2018. The calculation of several bioclimatic indexes, namely Hugin index, cool night index and dryness index, indicated that 2017 was the warmest year of study. Overall, treated grapevines showed higher water use efficiency and net photosynthesis, particularly in 2017, suggesting that climate plays a primary role in triggering grapevine summer stress responses and kaolin efficiency. Treated grapevines showed lower leaf temperature and an opposite response regarding chlorophyll accumulation throughout the 2017 summer season. While treated grapevines from Alentejo showed higher chlorophyll content compared to untreated vines, kaolin application in the Douro region promoted features of high light acclimated plants, such as increased Chl a/Chl b and lower Chl/Car ratios. Nevertheless, the accumulation of carotenoids, particularly the xanthophyll cycle pool pigments, increased in kaolin treated plants, whereas the non-photochemical quenching (NPQ) decreased, revealing the multiple functions of carotenoids in the photoprotection mechanisms. Our results suggest that kaolin application boosted a defensive response to increased summer, improved anthocyanin levels, and modulated the levels of abscisic (ABA) and salicylic (SA) acids throughout ripening. Despite the climate dependence and all the possible sources of variability under field conditions, kaolin application improved grapevines' ability to deal with prolonged periods of summer stress, optimizing their ability to control light absorption and use efficiency. Acknowledgements:

This work was supported by National Funds by FCT under the project UIDB/04033/2020 and the doctoral programme AgriChains (PD/BD/128273/2017). Sara Bernardo acknowledges the project I&D&I AgriFood XXI operation NORTE- 01-0145-FEDER-000041, co-funded by FEDER through NORTE 2020).

Grapevine Ripening Models based on sugar concentration and temperature for the viticultural C a Region, Douro Superior, Portugal

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Abstract

Increasingly warm and dry climate conditions are challenging the viticulture and winemaking sector. Digital technologies and crop modelling bear the promise to provide practical answers to those challenges. As viticultural activities strongly depend on harvest date, its early prediction is particularly important, since the success of winemaking practices largely depends upon this key event, which should be based on an accurate and advanced plan of the annual cycle. Herein, we demonstrate the creation of modelling tools to assess grape ripeness, through sugar concentration monitoring. The study area, the Portuguese C a valley wine region, represents an important terroir in the "Douro Superior" subregion. Two varieties (cv. Touriga Nacional and Touriga Franca) grown in five locations across the C a Region were considered. Sugar accumulation in grapes, with concentrations between 170 and 230 g l⁻¹, was used from 2014 to 2020 as an indicator of technological maturity conditioned by meteorological factors. The climatic time series were retrieved from the EU Copernicus Service, while sugar data were collected by a nonprofit organization, ADVID, and by Sogrape, a leading wine company. The software for calibrating and validating this model framework was the Phenology Modeling Platform (PMP), version 5.5, using Sigmoid and growing degree day (GDD) models for predictions. The performance was assessed through two metrics: Root Mean Square Error (RMSE) and efficiency coefficient (EFF), while validation was undertaken using leave-one-out cross-validation. Our findings demonstrate that sugar content is mainly dependent on temperature and air humidity. The models achieved a performance of $0.65 < \text{EFF} < 0.92$, with an error of $2.90 < \text{RMSE} < 5.87$. Overall, the behaviour of the two cultivars was similar, whereas the atmospheric variables provided suitable modelling of technological maturity. The models provided herein may help growers to better define and plan their annual activities, thus being a key decision support tool in viticulture.

Evaluation of the water status of the vine crop, using the CWSI (Crop Water Stress Index)

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Abstract

Climate change does not happen in the distant future, but it is already present in our daily lives. The increase in temperature and decrease in precipitation volumes has gained prominence, making current and research work as a focus to overcome the constraints imposed by these two elements of the climate. The process of optimizing the use of water resources will be essential so that crops continue to produce and do not suffer productivity losses, since water is one of the most limiting resources for crop productivity. The use of unmanned aerial vehicles (UAV) associated with thermal imaging cameras is a fast, reliable, and non-invasive alternative to assess the leaf water balance of crops. The present study aimed to analyze almost in real-time the water stress of a vineyard located in Porto Moniz (Madeira) - Portugal, in two periods of its vegetative development, using the processing of thermal images acquired by a UAV. Analysis of the data obtained shows that, even in the area cultivated with a single variety, the lack of water occurs in a very different way across the analyzed surface. The use of the CWSI index presented results, a context on the water status of plants at the time of the UAV passage over the land. These results can bring great benefits to the producer, as it allows him to supply water to the crop, in a more precise, efficient, and economical way, seeking to maintain production and still using water resources more efficiently.

Evaluation of “crop forcing” as a strategy to mitigate climate change in the vineyards of douro region

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Abstract

Douro Demarcated Region is characterized by its typically Mediterranean climate, with severe water and heat stress during the grapevines growing season. Under global warming, the projections point to warmer and drier months having strong effects in grape production by leading to fruit ripening in warmer months, which affect negatively the yield and quality of grapes and wines. In this context, the study of new techniques of training, such as Crop Forcing (CF) are becoming major challenges. CF can be defined as a practice that forces vine regrowth through a second pruning performed after fruit set, by removing all the leaves and clusters, aiming to delay fruit ripening and shifting it to cooler months of the year. The work presented was a field trial conducted in 2019 in an organic property of Symington Family Estates, located in Douro Superior sub-region. Three modalities were established: Control, without CF (CF0), CF performed 15 days after fruit set (CF15) and 30 days after fruit set (CF30). The effect on phenology, canopy development, water status monitoring, fruit composition and number, weight and length of clusters was assessed. Regarding phenology, as expected, the cycle was delayed on those plants subjected to CF. The agronomic results obtained, showed lower leaf area in CF1 and higher on CF2, a reduction of clusters size, clusters weight and number in both CF treatments comparing to CF0 and also differences in must quality, in general with lower pH and higher total acidity on CF treatments comparing to CF0. To conclude, as expected, a second pruning had visible effects on delaying phenology stages. Also, CF had also showed visible effects in yield and quality of musts. Regarding the water stress, the CF methodology didn't have significant effects, being the results similar in the three modalities. Further work is required to monitor and validate the impact of the CF in the region.

Effect of indolebutyric acid (IBA) and a bioestimulant on the rooting of *Vitis vinifera* cuttings

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Abstract

Given the impact of the national wine sector, it is important to develop techniques that promote the rooting of cuttings by the application of substances, which affect initiation, number and length of roots. In this study, the effect of indole-3-butyric acid (IBA) 0.8% and a commercial bioestimulant at 100, 50 and 0% (control) concentrations was analysed in cuttings of Alvarinho and Fernão-Pires varieties. The assay was performed in a walk-in growing chamber under controlled environmental conditions (photoperiod, radiation, temperature and relative humidity) from the laboratory of CITAB (Vila Real, Portugal). Growth and morphological features of roots and leaves were determined like: number, area and dry weight. The histological study of roots was also performed including, the root diameter, dimension of the cortical zone and central cylinder. Fernão-Pires revealed higher rooting and bud break percentage, and in general overperformed Alvarinho in growth. The treatments with IBA and bioestimulant 50% had higher rooting rates, while IBA was responsible for the higher bud break percentage. Cuttings with 100% bioestimulant showed increased root growth (e.g., root number) and lower growth of the aerial part. Conversely, IBA potentiated the aerial part but not the roots when compared with bioestimulant 50% and 100%. However, bioestimulant 50% increased the diameter of the roots and the central cylinder, when compared to control plants. Thus, it is concluded that the application of growth promoters had significant effects on the root and aerial parts and can be used as an important cultural practice for nurseries and vinegrowers. The present results indicate that this methodology may be used in different grapevine varieties and wine regions.

Evaluation of different types of pheromone dispensers used in mating disruption against *Lobesia botrana*, under Douro Demarcated Region conditions

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Abstract

The increased regulation of pesticides use in Europe (Directive 128/2009/EC), together with the public concerns about the environmental impacts of viticulture and the consumers demand of residue-free products, led to the development, in the last years, of environmentally safe pest control strategies in European vineyards. Mating disruption (MD) is a biotechnical pest management strategy that can be used against the grapevine moth, *Lobesia botrana* (Den & Schiff.), a key-pest in the Douro Demarcated Region (DDR), being widely recommended in Integrated Pest Management. Despite the effectiveness of MD in *L. botrana* control, some constraints have been previously identified in Douro Demarcated Region (DDR) vineyards, some of them related with climatic conditions (i.e. high summer temperatures and wind speed) and with steep slope conditions (i.e. altitude, exposition), which can lead to the exhaustion of pheromone in dispensers, before or during the third flight of the pest. In this study, carried during 2020 and 2021, in two DDR farms, it was intended to evaluate, over time, the amount of pheromone released from different types of “passive” dispensers registered in Portugal (i.e. ISONET-LTT[®], BIOOTWIN[®], LOBETEC[®]), in order to understand the effect of temperature, wind speed, altitude, and location of MD treated area. Generally, the results shows that pheromone available in the evaluated dispensers exhausted at the end of July, or during August. The results also allowed the identification of differences in amount of pheromone released, according to different dispensers, locations, and altitude. The higher release rate of pheromone was found in 2020, at lower altitude.

Variation in must polyphenols concentration in a Verdejo Negro clone (*Vitis vinifera* L.), grown at different altitudes in a mountain viticulture area.

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Abstract.

The Asturian viticulture area (north of Spain) gathers altitude and slope characteristics of mountain viticulture, acknowledged by international organisms such as “heroic viticulture”. The existing grapevine varieties have been described in previous studies. Clones of some of these varieties have been commercialized since 2007, Verdejo Negro among them, an autochthonous black berry grapevine variety, used to elaborate high quality red wines in this area. The number of studies involving polyphenols in *Vitis vinifera*, both in the fruit (peel, pulp, seeds) and in the processed products (musts and wines), have increased in the last years due to their demonstrated benefits in human health (great antioxidant capacity, anti-inflammatory properties, anticarcinogenic and antitumor, etc.). These compounds have also revealed important implications in plant resistance against biotic (fungal diseases) and abiotic stresses (water stress, drought, ultraviolet radiation).

It is well known that polyphenol concentration can differ depending on the fraction analysed (grape, must or wine), but there are several other factors that could influence the content of these compounds, genetic (variety/clone, rootstock...), agronomic (ripening, berry size, total acidity...) or oenological, i.e. the winemaking process (white or red wine) or the maceration time. The edaphoclimatic conditions and other characteristics of the plot (altitude, orientation) as well as the crop management practices (pruning, training system) have effects in grapevine secondary metabolism (synthesis of polyphenolic compounds) and therefore in the final composition of musts and wines.

The aim of this work was to analyse the must polyphenolic profile of a single Verdejo Negro clone, grown in plots with different characteristics and located at different altitudes within the Denomination of Origin Cangas (Asturias, Spain). High Performance Liquid Chromatography coupled to a Mass Spectrometer (HPLC-MS) was used for this purpose.

The results obtained for this clone showed a great plot dependant quantitative diversity in the total polyphenolic and anthocyanin concentration. The detection of flavanols in the musts from some studied plots was also remarkable.

Application of plant-based coagulants with solar-Fenton as an economic and environmentally safe process for winery wastewater treatment

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Abstract

The winery wastewater (WW), is a major waste stream resulting from cleaning of vats, washing of floors and equipment, rinsing of transfer lines, barrel cleaning, product losses, bottling facilities and filtration units. The environmental impact of the WW is notable due to the pollution of water, degradation of soil and damage to vegetation arising from wastewater disposal practices, odors and air emissions resulting from the management of wastewater.

To reduce the pollution load of this problematic wastewater it was explored, in this work, the combination of coagulation-flocculation-decantation (CFD) with photo-Fenton process, with the aim of (1) produce and characterize plant-based coagulants for WW treatment, (2) optimize photo-Fenton process and (3) study the efficiency of combined CFD-solar photo-Fenton at pH 3.0 and 6.0.

Plant-based coagulants were constituted of pollen (*Acacia dealbata* Link.), acorn skin (*Quercus ilex* L.), peeled acorn (*Quercus ilex* L.), seeds (*Platanus x acerifolia*) and seeds (*Tanacetum vulgare* L.). Fourier transform infrared spectroscopy (FTIR) analysis showed the presence of proteins, polyphenols and carbohydrates and scanning electron microscope (SEM) presented empty spaces and irregular shapes of the plant-based coagulants, therefore, revealing good adsorption properties. After 12 h of

sedimentation period, it was observed a chemical oxygen demand (COD) removal of 46.6, 42.0, 46.6, 48.2, 52.8%, respectively for the five coagulants mentioned. As a complement to CFD, it was optimized the photo-Fenton process by variation of hydrogen peroxide dosage (87-349 mM), Fe^{2+} dosage (1.0-10 mM), different catalyst types (cobalt, copper, iron, magnesium, manganese and zinc), Ethylenediamine-N,N'-disuccinic acid (EDDS) dosage (1.0-10 mM), hydroxylamine hydrochloride (HA) dosage (1.0-10 mM) and variation of radiation type (UV-C, UV-A and solar light). Under the best operational conditions: Solar radiation, $[\text{Fe}^{2+}] = 5.0 \text{ mM}$, $[\text{H}_2\text{O}_2] = 175 \text{ mM}$, $[\text{EDDS}] = 1.0 \text{ mM}$, $[\text{HA}] = 1.0 \text{ mM}$, agitation 350 rpm, time 240 min, temperature 298 K, it was achieved a COD removal of 87.7, 88.2, 90.8, 92.4 and 91.4%, at pH 3.0 for the five previously mentioned coagulants. Considering these results, the application of plant-based coagulants in combination with solar-Fenton is an efficient and economic process for WW treatment.

Cultivation of green microalgae in winery wastewater

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Abstract Attending to the volume and composition of winery wastewater (WW), the environmental impact from its direct discharge into water courses is of great concern. In this work, microalgae have been used to remove chemical oxygen demand (COD), nitrogen, phosphorus and polyphenols from WW. *Chlorella vulgaris* and *Auxenochlorella protothecoides* were grown on washing-derived WW, using bubble column photobioreactors (PBRs) which operated under batch regime. More than 90% of COD, nitrogen and nitrates and more than 70% of phosphorous were removed. Polyphenols was the group of pollutants that was the most difficult to remove (50%). This bioremediation strategy showed a reduction in the phytotoxicity effect of the effluent in the germination index of corn, cucumber, onion and tomato seeds.

Acknowledgments

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THEMATIC AREA 3

Quality factors for "wines"

Assessment of the technological aptitudes and quality production of the grapevine varieties in the Pietroasa vineyard

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Abstract

Many varieties of grapevine do not have relevant technological potential, or the quality of the grapes is not in line with the increasing requirements of wine producers and consumers. Therefore, the research on this paper aims to assess the mechanical structure and the uvologic indexes values of two grapes varieties: Fetească regală (FR) and Cabernet Sauvignon (CS), cultivated in Pietroasa vineyard (Romania). The technological aptitudes based on the uvological indexes analyzed are within the specific intervals for the grapes intended for the production of wines of superior quality. This is also demonstrated by HPLC-RID analyzes on the grapes and must of the two varieties studied. The values of essential constituents such as sugar content (FR grapes 210.9 g/l and must 216.2 g/l; CS grapes 190.6 g/l and must 244.6 g/l) and acidity content (FR must 4.5 g/l CS must 6.4 g/l) demonstrated superior quality. The percentage values of fructose and glucose demonstrate that there was a higher fructose content in the analyzed must (CS must 11.4% and FR must 10.5%). In addition, the HPLC-RID method has also been shown that the values of the Ochratoxin A content in must (FR must 1.03 µg/kg and CS must 1.12 µg/kg) do not represent a food safety risk.

Harvest time and withering length: combined effect on the phenolic composition of Nebbiolo grapes destined to the production of Valtellina Sfursat DOCG wine

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Abstract

Sforzato di Valtellina is a DOCG reinforced wine produced from *Vitis vinifera* L. cv. 'Nebbiolo' grapes grown in the steep slopes of the Valtellina alpine valley (Northern Italy) and then subjected to partial postharvest dehydration/withering. The grape ripeness degree and the withering process strongly influence wine quality. The aim of this research was to assess the combined effect of different ripeness levels and withering length on the standard chemical composition and phenolic profile of 'Nebbiolo' wine grapes destined to the production of Sforzato di Valtellina wine. During three consecutive vintages (2019-2021), three binomial harvest/withering treatments have been tested: early harvest/long withering (EL), medium-term harvest/medium-term withering (MM) and late harvest/short withering (LS). Grape samples from two vineyards at different locations (Valtellina upper and lower valley) were harvested and placed into a typical 'fruttaio' dehydration room. Grape must composition, mechanical parameters, and extractable phenolic profiles (total polyphenols, total anthocyanins, total flavonoids, and methylcellulose tannin assay) of grape skins and seeds were studied before and after the withering process, which lasted until December 1st according to production regulations, and resulted in a grape weight loss of about 20, 17 and 15% for EL, MM, and LS samples, respectively. The data obtained at the end of withering for first two vintages underlined that EL thesis showed the highest values of sugars and acidity, and the lowest pH. Total polyphenols, flavonoids, and tannins extracted from seeds showed a decreasing trend when grapes were late harvested (LS). Instead, skin-extracted phenolics were less influenced by the harvest time, whereas their concentration expressed on grape weight increased after withering. Skin extractable anthocyanin experienced a distinct trend for the two vineyards studied. In conclusion, harvest time and withering length can be modulated according to the desired oenological objective, promoting the valorisation of grape potentialities.

The vulnerability of vineyard soils to Copper contamination: how soil properties affects its mobility and toxicity to aquatic organisms

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Abstract

The use of Cu-based fungicides to prevent diseases in organic and conventional viticulture may cause serious environmental problems, resulting in negative impacts on soils-organism functions and diversity, and on vineyards surrounding ecosystems. Levels of Cu found in European vineyard soils may affect not only non-target soil organisms, but also aquatic organisms. Indeed, despite its low mobility in soils, there is a risk of surface and groundwater contamination, depending on soil properties (e.g.: pH, organic matter content and texture) and levels reached. Thus, the objective of this work was to evaluate Cu mobility and bioavailability for aquatic organisms, in soils with different physical and chemical properties. For this purpose, ten vineyard soils with variable soil properties were collected from different wine regions from Portugal and Spain and were later contaminated in the laboratory with different concentrations of Cu (0, 46, 72, 112, 173, 268, 416, 645 and 1000 mg kg⁻¹) using Bordeaux mixture. After one month of incubation, ecotoxicological tests were carried out with aquatic organisms (*Aliivibrio fischeri*, *Raphidocelis subcapitata* and *Lemna minor*), following standard guidelines. In parallel, the mobility and availability of Cu was assessed through leaching experiments in soil columns, water and DTPA batch experiments. Results allowed to understand which soils may increase the vulnerability of aquatic resources to contamination by Cu, through its transference to these systems (especially when the pH of soils is low), at concentrations capable of causing negative effects on aquatic organisms.

This work was supported by: FEDER INTERREG SUDOE Programme (Coppereplace Project-SOE4/P1/E1000); by FCT within the scope of UIDB/04423/2020 and UIDP/04423/2020, UIDB/05748/2020 and UIDP/05748/2020; and through individual financing to A. Cachada (CEECIND/00058/2017) and B. Fernandes (UI/BD/151040/2021). D. Fernández-Calviño contract was financed by the Spanish Ministry of Economy Industry and Competitiveness (RYC-2016-20411); and C. Campillo-Cora fellowship (ED401A-2020/084) by Xunta de Galicia.

The contribution of yeasts to the specificity of the wine terroir: a review

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Abstract

Microbial diversity in the winemaking process, with a significant influence on the wines themselves, includes *Saccharomyces* and non-*Saccharomyces* yeasts. The transformation of the grape must into wine is mainly the result of the activity carried out by these yeasts. Although many commercial inactive and active dry wine yeasts are involved in the winemaking process today, only a few wineries use these yeasts to preserve the terroir concept with the help of local yeasts. This paper reviews studies on the use of dry yeasts produced from isolated autochthonous yeasts, *Saccharomyces* and non-*Saccharomyces*, involved in various wine-growing areas and which play a significant role in the wine terroir.

Silicon application effect on berry quality of Touriga Franca variety in the Douro Demarcated Region

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Abstract

It is known that warmer and drier climate will challenge Portuguese viticulture, with a negative impact on the economy, particularly for renowned winemaking regions such as the Douro Demarcated Region.

In the context of climate change, the production of grapes and the sustainability of the vineyard are vulnerable to the effects of high radiation, heat and drought during the summer period, negatively affecting the vines at the phenological, physiological and biochemical levels. The shortage of water resources makes irrigation practically unsustainable from an economic and environmental point of view, being crucial to implement alternative and eco-friendly measures for a better balance between vines and the environment, helping to mitigate the effects of climate change. Thus, it is necessary to create strategies to adapt to water stress. In this work, we applied a suspension of silicon (2.5 %) in a commercial vineyard located in the Douro Superior sub-region (Santa Comba da Vilarica locality; 41°20'49,79" N 7°03'44,81" W) to understand its effects on increasing tolerance to water stress in Touriga-Franca grapevines.

The experiments were divided into three treatments: i) positive control - with a deficit irrigation (25% of ET_c), ii) negative control - without irrigation and iii) silicon - SiO₂, applied between veraison and harvest. After the statistical analysis by the SPSS program, the results showed that, at veraison, silicon treated fruits presented higher significant values of total phenols, flavonoids, pH, malic acid, total soluble solids (brix°) and reducing sugars when compared with both irrigated and non-irrigated ones. At harvest, the silicon treated plants showed fruits with higher anthocyanins, pH, malic acid, brix° and reducing sugars content than the negative control. Accordingly, we can suggest that silicon foliar treatment could be an alternative to deficit irrigation strategies to mitigate water stress without negative impact on berry quality.

Effect of mountain viticulture conditions on cv Blanco lexítimo aroma potential in Ribeira Sacra AOC

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Abstract

Ribeira Sacra, located in the Northwest of the Iberian Peninsula, is one of the wine production areas of NW Spain. The vineyard is planted in terraces with very steep hills (400–500 m) in the valleys of rivers Miño and Sil. The main red grape variety grown in Ribeira Sacra AOC is *Vitis vinifera* Mencía. During the last few years, there has been a growing interest in the recuperation of the denominated autochthonous varieties from Galicia. This is the case of Blanco lexítimo *Vitis vinifera* grape variety, an aromatic white cultivar traditionally grown in Betanzos (North of Galicia). This work reports the results of the first study on aroma potential of Blanco lexítimo, grown in Ribeira Sacra with the aim to know the adaptation of this cultivar to the mountain viticulture conditions in Ponte da Boga vineyards. Grapes of Blanco lexítimo, collected in 2018 vintage, were crushed and the musts volatiles were extracted using Solid Phase Extraction (SPE). The identification and quantification were performed by gas chromatography-mass spectrometry (GC-MS). Twenty-eight compounds were quantified in free fraction and thirty-six in bound fraction, grouped in several families: alcohols, C6 compounds, volatile acids, aldehydes, lactones, volatile phenols, terpenes and C13- nor isoprenoids. With respect to varietal compounds (terpenes and C13-norisoprenoids), the results showed a higher content of glicosidically fraction than free fraction. In free fraction, C6 compounds (vegetal aroma) showed the highest concentration, however terpenes and C13-norisoprenoids (floral and fruity aroma) reached the highest concentration in bound fraction.

Applying empiric models to study the grape total soluble solids dynamics

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Abstract

Grape sugar increase during ripening has been considered as cultivar or site specific and depend of many environmental conditions and production technologies. Crop load balance is also referred as an important factor influencing sugar content, but its dynamics is not always understood. In this work, empiric models were developed to study the relation between crop load balance and sugar dynamics during ripening. Total soluble solids (TSS) was measured in grape samples between veraison (colour change) and harvest at several vineyards from “DO – Beira Interior” region (Portugal), in 2017 and 2018 seasons. At harvest, ‘Síría’ and ‘Aragonês’ cultivars yield and canopy dimensions were measured in individual plants. Samples for TSS analysis were also collected by each individual vine. Empiric models (non-linear equation) from sugar content (TSS, g/L or potential alcohol content) measured as function of crop load balance (kg/m^3 vine volume) were developed for each case (vineyard and season). A degree-days model (modified Mitscherlich equation) was developed for sugar content, estimated by the former model for the same crop load balance in all vineyards and seasons. Considering that yields remain even between veraison and harvest, sugar content vs. crop load balance, in individual plants, was simulated for each sampling date. Graphic representation for those simulated results showed almost horizontal curves at veraison, indicating low or null crop load balance effect on sugar content, and confirming that veraison is the last chance for cluster thinning. Simulated curves become progressively more vertical, suggesting that crop load effects enhanced progressively until harvesting, interacting with temperatures (heat accumulation), water stress, and/or other environmental effects or production technologies. Furthermore, graphic representation of simulated results for the same date can be used to separate crop load balance effects (along the curves) from site (mainly heat accumulation) effects (different curves), illustrating the interaction dynamics. By simulating results for the same heat accumulation, in all sites, sugar content becomes only influenced by crop load balance, which indicates that the final sugar content, at normal environmental conditions, is mostly dependent from management decisions (pruning level, cluster thinning and harvesting time). Conjugating those two models allows to simulate the optimal harvest period for different crop load balances.

Acknowledges: this work has been supported by the “Projeto Estratégico de Apoio à Fileira do Vinho na Região Centro” (CENTRO-04-3928-FEDER-000001).

THEMATIC AREA 4

People, history, economics and culture.

Evaluation of the costs associated with two types of grapevine pruning: guyot and cordon royat

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Abstract

Among all the vineyard operations that are carried out annually, winter pruning is one of the most important in terms of productivity and quality of the grapes and labor costs. The two types of pruning most used in the Douro Demarcated Region are Guyot and cordon Royat.

The objective of this study was to compare the time spent on each type of pruning. The experiment took place in a vineyard located in the town of Santa Comba de Vilariça (Bragança, Portugal) (41 ° 20'49.4 "N, 7 ° 03'44.3" W, 226 m a.s.l). The vineyard was planted in 2014 with 1103 P rootstock and the Touriga Franca cultivar (*Vitis vinifera* L.) with a trellis system. In 2021, homogeneous blocks of 5 vines formed in the two types of pruning were randomly selected to evaluate the time of the pruning operation. The three phases timed separately, within the pruning operation itself, were: pruning, removing the pruning wood from the wires and tying the shoots (only in the Guyot system). The experiment was carried out with 3 experienced professional pruners and manual pruning shears. The results showed significant differences in terms of the total pruning time, being necessary 4351 hours per hectare to carry out Guyot pruning and 2377 hours per hectare for cordon Royat pruning. Within the different phases of pruning, the tying of the shoots, was the one that increased the total hours of the Guyot system in comparison with the cordon Royat. To conclude, we could suggest that this same test could be carried out with the help of an electric tying machine, which could mean a significant reduction in time in the Guyot system.

Viticulture in the Douro Demarcated Region: a systematic literature review to promote a sustainable future

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Abstract

This paper aims to provide an overview of the state of the art in research on viticulture in the Douro Demarcated Region (DDR), identifying the characteristics of research efforts and trends in this thematic area. A quantitative bibliometric analysis was performed on articles specifically focusing on DDR viticulture that had been published in journals indexed in the Web of Science (WoS) and Scopus databases. The methodology and research design were based on an inductive approach to a corpus of studies and aimed to plot theoretical developments to date in this field of research. Twenty articles on this topic were found, dating from 2010 to 2021, with most of the articles being published over the last 3 years (2019-2021). Four trends in the research undertaken were identified: climate change projections in viticulture; habitat diversity for DDR vineyards; technologies for higher efficiency and productivity of vineyards; and business innovation strategies for viticultural enterprises. The co-citation analysis revealed a focus on habitat management and groundcover studies. Furthermore, by using the most rigorous bibliometric analysis, it was also possible to identify which specific authors, journals, organizations, and countries/regions had contributed to the development of research on this topic. This analysis not only improves our understanding of the paths recent research has taken but also serves as a guide for future research in which climate change mitigation and technological innovation will be key priorities.

The "Ruta del vino de Gran Canaria"

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Abstract

Here we present the "Ruta del vino de Gran Canaria" as a cultural project that aims to: a) make perceivable the work of the winegrowers; b) exploit the value of the wine produced in the island, and c) preserve the island's wine cultural heritage and make it profitable. The process to realize the "Ruta" is based on two pillars already presented by the authors at previous CERVIM conferences: the first island's capital i.e. the landscape as a means of production; the second is the mapping of vineyard landscape productive of Gran Canaria with heroic viticultural practices. The project started in 2017 promoted by the Council of the Primary Sector and Food Sovereignty of the Cabildo de Gran Canaria and its process is developed to 2019 from 2020 thanks to LEADER funding. The "Ruta" has been certified in 2021 and now involves 59 partners related to the wine culture and promotion for a total vine-growing area of 210 hectares scattered all over the island. These numbers provide an agile measure of the landscape fragmentation and reflect the "structural" difficulty to cultivate. To overcome such difficulties, the winegrowers developed inventive agronomic practices that integrated into the cultural heritage of the island. These characteristics are reflected in its unique viticultural landscape illustrated by the vine-growers and the wine-makers of the "Ruta". And, to make this link between culture, landscape and wine even more significant, the motto "Hacemos vinos y embotellamos paisajes" (We produce wines and we bottle landscape) was coined. To conclude, we believe that the theoretical foundations found in the "Ruta del Vino de Gran Canaria" can be profitably used to enhance wine production, preserve the traditional viticultural landscape and raise awareness of the high-quality products of the island's primary sector.

Terroir Madeira: a purpose reencountered, (trans)formations in the architecture of the viticultural landscape

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Abstract

How has the vine-culture been constructed in Madeira Island's landscape and architecture? The present study aims to understand the viticultural territory through its representation. The vertical section drawing is applied to understand the functions, qualities, and weaknesses of Madeira viticultural small-scale terraced landscape, considering the multidisciplinary of its stakeholders. Due to the absence of scientific studies regarding this matter, experimental maps, interpretative drawings, and photographic reportages were made in parallel to on-site surveys and interviews with local people. The vertical section is used not only as a project tool but also as a thought process that interprets and articulates different methods, such as the vertical sections of Alexander von Humboldt and The Valley Section of Patrick Geddes. The study is made through a series of sections along the island structured in three main scales: regional, local and property plot. Through an analysis of the organization of agricultural structures, it shows that the intensity of viticulture depends on the availability of infrastructures and is divided into three major moments: highly productive, abandoned or partially maintained. It has been recognized that natural disasters, such as floods and fires are the biggest threats arising from agricultural abandonment. Moreover, unreasonable architectural interventions are gradually compromising the landscape's attributes such as the ancestral dry-stone terraces - poios, the water transportation system - levadas, or the vineyard structures - latadas. In conclusion, there is a necessity to safeguard the viticultural landscape's specificities in the problematic range from 300m to 800m a.s.l. The accelerating and uncontrolled transformations that threaten the population's security and the survival of viticulture must be debated. This study raises awareness to reflect on territorial contemporary dilemmas and discuss sensitive architectural solutions that combine traditional long-tested practices and technological innovation.

Terraced vineyards and heroic viticulture in Primorska winegrowing region

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Abstract

Slovenia has three winegrowing regions: Podravje, Posavje and Primorska. Primorska winegrowing region is situated from the western to southwestern part of Slovenia and consists of four winegrowing districts Goriška brda (Brda), Vipavska dolina (Vipava), Kras and Slovenskastra. According to the topography, Brda and Vipava are known for heroic viticulture, where vineyards are arranged on steep slopes with inclinations over than 30%, and almost 70% of the vineyards are terraced. Moreover, approx. 1.800 ha in Brda and 2.150 ha in Vipava district are covered by vineyards, where the synergistic impact of soil, climate and topography characterizes a traditional landscape. Data of heroic viticulture in Brda and Vipava includes soil and climate characteristics, surface (size) and age of single vineyard, grapevine assortment, terrace constructions, etc. Data was obtained from the Register of grape and wine producers (RPGV) and the Slovenian Environment Agency (SEA) and analysed separately for Brda and Vipava district. The range of terraced vineyards is influenced by environmental conditions, knowledge, tradition, as well as the economic situation in the sector.

Route de vignoble alpins: alpine viticulture and value

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Abstract

The project “The route devignoble alpins”, is an european project Interreg Alcotra2014-2020. The goal is to enhance wine tourism in the Franco-Italian Alps. The project partners are the Metropolitan City of Turin, the Pays of Savoie, Valle d'Aosta. The aim of the project is the defense and promotion of the landscape of heroic viticulture and vines with a strong identity and the development experiential tourism.

The research is based on the following approach:

- Survey of a sample of tourists in order to know if they are aware of AostaValley wines and have consumed or purchased them, in which sales or accommodation facilities they had the opportunity to drink AostaValley wines, and if they have seen or visited the wine-growing landscapes of the region and what opinion they have of these landscapes;
- Collection of a targeted questionnaire through a direct interview with as ample of operators in the tourism sector (hotels, restaurants, operators in the field of oenology) aimed at verifying whether they sell wine products from the Aosta Valley, to know their opinion on the relationship between product quality and landscape and what are any problems that have limited/prevented the sale of AostaValley wine.

Some winemakers have picked up the baton of their parents but many are those who come from other sectors or from different family experiences who have decided to embark on a professional and personal bet by investing with passion, innovation and professionalism. The winegrowers are in possession of a good level of education, some are graduates in agricultural disciplines and women become an integral part of the category of wine producers often with good results. From the analysis of the data, the picture of adynamic viticulture emerges, mainly made up of adults who, due to training or personal choice, have decided to undertake the work of the winemaker.

New growth of Demarcated Douro region cluster – cluster life cycle perspective

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Abstract

The present research is a case study of the Demarcated Douro Region (DDR) from cluster life cycle perspective. The Cluster Life Cycle (CLC) theory is one of the prominent research areas on clusters dynamics. It considers that clusters can develop and go through stages of birth, growth, maturity, decline or renovation. Determining the stage of the cluster life cycle allows to identify relevant policies and firms' strategies going beyond its static understanding. This study identifies the present stage in the life cycle of DDR's cluster. First the appropriate model for the identification is proposed based on the analysis of the following parameters: cluster brand; number of companies; number of employees; exit to foreign markets - export/IDE, markets; network; policies and regulations; innovation. The study analyses data since 1945 and draws a conclusion. Since the 90s the Demarcated Douro Region has gone through the "path transformation" where new "anchors" for the cluster was introduced, such as Doc Douro Wines, other forms of Port Wine consumption, tourism, olive oil. Since 2010 the cluster entered the (new) path development, where this "anchors" are at steady growth. There is an increase in the number of companies in general, and specifically in the viticulture area - from 2011 to 2020 the number of operators in Port wine has increased 55% and in DOC wines 85%. Additionally, an exponential increase on sales to more distant markets and the entry into many new markets. Networks undergo restructuring due to the entry of multiple new operators and associations that reorient the entire cluster (e.g, Douro Boys, in 2009 establishing DDR as a cluster, National Cluster of Vine and Wine in 2017). Followed by several government support actions and innovation growth (number of patents). The conclusion is that the DDR cluster is entering a new growth stage of its life cycle.

Estimation of Total Factor Productivity in the presence of spatial dependence and transient and persistent inefficiency: Evidence from Portuguese wineries

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Abstract

In recent decades, globalization in the wine industry has been providing conditions for increased competition, with new entrants in the market and the rise of substitute alcoholic beverages. In such a scenario, only the most efficient firms thrive in the market, making the assessment of technical efficiency and the measurement of Total Factor Productivity (TFP) and TFP growth key to firm managers and policy makers as a tool for evaluation of strategies. Recent developments in efficiency literature made possible to account for spatial dependence and at the same time, to disentangle between short- and long-term efficiency. These features are of particular importance in industries where location is a crucial determinant of competitiveness, such as the case of the Portuguese wine industry. This paper computes and analyzes the TFP of a representative sample of Portuguese wineries, covering a period from 2014 to 2020, departing from a spatial stochastic frontier model that accounts for the separation between short- and long-term inefficiency. The advantages of using a spatial stochastic frontier model are discussed. The results show that TFP and TFP growth measurements are sensitive to model specification. Moreover, spatial spillovers are identified and found to impact these measurements. Finally, we confirm that most productive firms (and regions) correspond to the most efficient firms as well.

Economic profitability of steep slope cultivating wine estates compared to flat terrain wine estates

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Abstract

Purpose: Viticulture in steep slopes is an important part of the viticultural heritage in many European winegrowing regions. Besides its direct economic value from grape growing it also serves as an important habitat for biodiversity and provides positive economic effects through tourism. Those positive external effects cannot always be internalised by grape growers who suffer from significantly higher labour efforts and therefore partly abandon steep slope vineyards, as in the example of Germany. This conference paper investigates the economic profitability of direct-selling wine estates cultivating steep slope vineyards compared to wine estates cultivating predominantly vineyards in flat terrain sites to estimate the effect of steep slopes on economic sustainability.

Methods: Business data from wine estates in Germany were used for the analysis, where steep slope vineyards are on the decline. The analysis is based on data derived from balance sheets, income statements and official statistics on vineyard acreage and yield of 408 wine estates from different German wine growing regions for the year 2013/14. Hereby, estates cultivating more than 50 % of their vineyard acreage in slopes, are referred to as steep slope estates. Besides Analysis of Variance of group differences the influence of different input factor, productivity and efficiency variables on profitability key figures are estimated using linear regression modelling.

Results: The analysis aims to answer the question to what extent steep slope sites in the vineyard acreage affect the profitability of wine estates. Results will be presented in due course.

Conclusions: Implication of the analysis will provide guidance for the economic sustainability of steep slopes and the future design of public policy.



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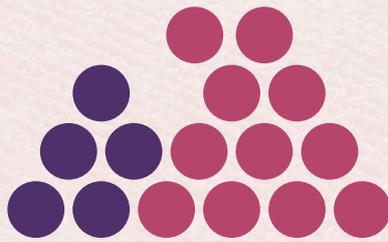


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MOUNTAIN AND STEEP SLOPES VITICULTURE